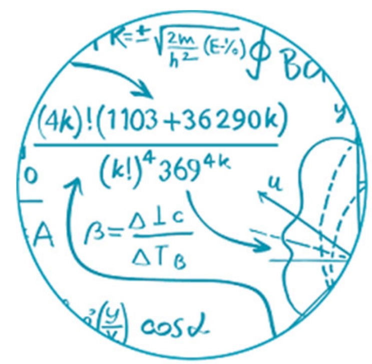
ROBECO
The Investment Engineers

Quant Investing: Today and Tomorrow

Weili Zhou, Managing Director, Head of Quant Equity Research
28th April, 2022



EDHEC BUSINESS SCHOOL

Agenda

- The rise of Robeco Quant
- Challenges we face today
- Leverage on Alt Data and ML/AI

Robeco: an investment company founded in 1929

> Seven prominent businessmen start an investment company in order to enable people to invest their money collectively

> Headquartered in Rotterdam, the Netherlands

Every investment strategy must be research-driven

L.W.E. Rauwenhoff, first CIO, 1934

A.C. Mees | D.G. van Beuningen | W.C. Mees | K.P. van der Mandele | Th. A. Fruin | W.H. de Monchy | H.C. Hintzen

Robeco Quant: introduced in practice since 1994

- Seven prominent businessmen start an investment company in order to enable people to invest their money collectively
- Headquartered in Rotterdam, the Netherlands
- The first quant model was developed in 1994, helping the fundamental managers to screen the universe
- Since then, quant research and business have grown rapidly

> Every investment strategy must be research-driven
>
> L.W.E. Rauwenhoff, first CIO, 1934

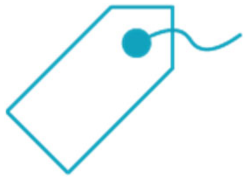
- 1929 Fundamental research and investment
- 1994 First Quantitative Stock selection model used in practice
- 1998 Quant dynamic duration strategy
- 1999 Quantitative Corporate bond selection model
- 2002 Core quant equities strategy
- 2004 Credit risk model (DTS)
- 2006 Conservative Equities – low vol investing; Quant EM equity strategy
- 2012 Momentum equities strategy
- 2012 Conservative credits strategy; Factor investing
- 2013 Value equities strategy
- 2015 Multi-factor credits strategy
- 2015 Factor Indices
- 2016 Quality equities
- 2017 Conservative Multi Assets
- 2018 Multi Factor Multi Asset

ROBECO

"Quant Equity – Investing in the right stocks at the right moment"

Our edge: embracing and going beyond academically proven drivers

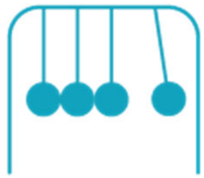
Value



Stocks that are inexpensive relative to their fundamental value generally outperform growth stocks

Price-to-book

Momentum



Past winning stocks tend to continue to appreciate and outperform past losing stocks

12-1 month

Quality

Financially healthy firms with strong balance sheets typically outperform lower quality stocks

Share buyback

Low Risk

Low-risk assets offer higher risk-adjusted returns than high-risk assets

Volatility

ROBECO

Our edge: embracing and going beyond academically proven drivers

We made groundbreaking contribution to the quant industry by

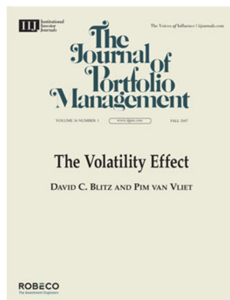
> Enriching the generic factor pool

> Enhancing academic factor definitions

> Extending research to different markets

> Examining factors in various asset classes

> Exploring practical investability



Low Volatility
2007

Award-winning paper in which we document and discuss the low-volatility effect, which forms the basis for our Conservative equities strategies.

Residual Momentum
2011

The performance of a momentum strategy can be improved significantly by removing unrewarded risks. Residual momentum forms the basis for our Momentum strategy.

Emerging Markets
2003

Value and momentum strategies are also highly effective in emerging equity markets, laying the foundation for our quant emerging markets strategies.

Factor Investing in the Corporate Bond Market
2014

Factors that are used successfully in equity market investing also work in the corporate bond market, laying the foundation for our Multi-Factor Credits strategies.

The catalyst: being one of the pioneers that integrate sustainability into quant strategies

70bn AuM
with 100%
sustainability integration

33bn+
Tailored ESG

ESG/SRI Provider
of the Year
European Pensions Awards
(2019, RobecoSAM in 2016)
European Pensions AWARDS 2019

Smart Beta and ESG Manager
2020
Pensions Expert

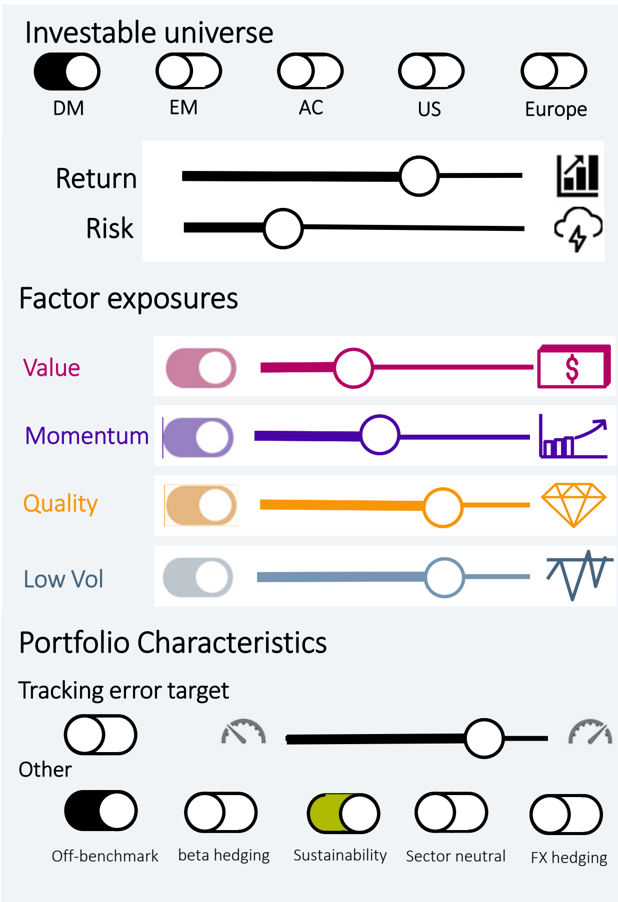
	1990s	Robeco's Quant Research
Founding of RobecoSAM	1995	
	1998	Quant dynamic duration strategy
Launch of Sustainable Equity Fund & Cooperation with Dow Jones	1999	Emerging Markets stock selection model
	2002	Core Quant Equity strategy
RobecoSAM member of Robeco Group & set up of Active Ownership team	2005	
Among the first to sign UN PRI	2006	Launch of Conservative Equities and EM Quant strategies
ESG integration in all capabilities	2010	
	2012	Factor Investing solutions & Conservative Credits strategy
Smart ESG scores introduced & Sustainable Quant Equities	2013	
Introduction Environmental footprint in portfolios	2015	Factor Indices & Multi-Factor Credits strategy
SDG framework	2018	Multi-Factor Absolute Return
Engagement and voting results reflected in portfolios	2021	Sustainable Indices

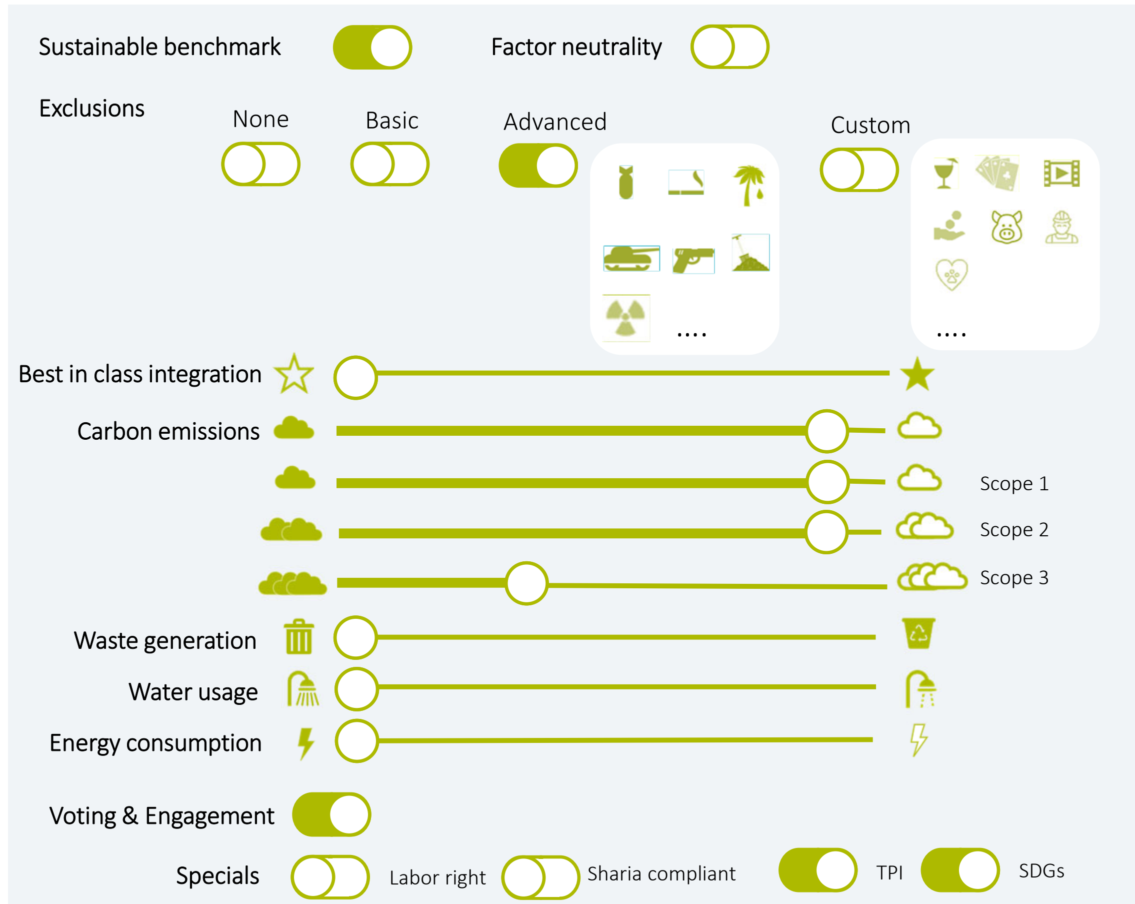
A+
for all modules
by the PRI
PRI assessment
2020
PRI Principles for Responsible Investment

Robeco #1 in ShareAction
responsible investment
assessment
ShareAction»

Best Factor Investing Manager
Asia Asset Managemt
2020
Asia Asset Management

The catalyst: offering unlimited customization possibility

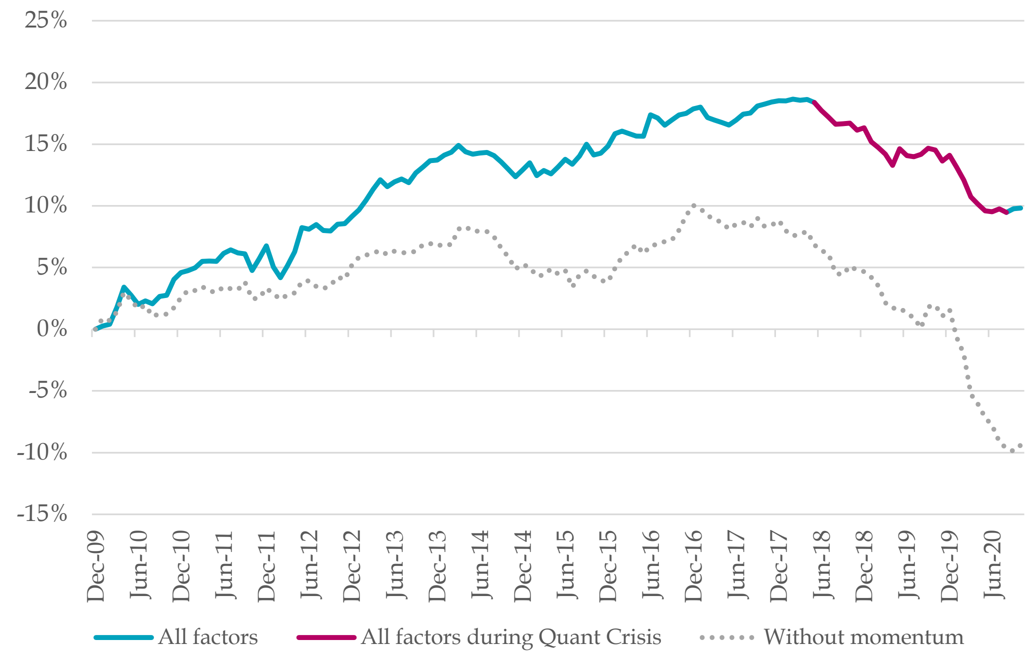




The quant business is going strong, but....are there serious challenges ahead?

Challenges: Lessons Learned from the recent Quant Crisis

Performance of a 1/N portfolio consisting of the size (SMB), value (HML), investment (CMA), profitability (RMW), and momentum (WML) factors in global developed markets



The Quant Crisis of 2018–2020:
Cornered by Big Growth

David Blitz

David Blitz
is chief researcher at Robeco in Rotterdam, the Netherlands.
d.c.blitz@robeco.com

KEY FINDINGS

- During the quant crisis of 2018-2020 there were many ways to fail but essentially only one way to succeed, namely by investing in the largest and most expensive growth stocks.
- Other factors were only effective to the extent that they provided implicit exposure to the same large growth stocks, and smaller stock portfolios underperformed across the board.
- Previous major drawdowns of the value factor were less challenging for multifactor investors because profits on the momentum factor exceeded the value losses.

ABSTRACT

This article examines the performance of equity factor portfolios during the quant crisis of 2018-2020. The author finds that there was basically only one way to outperform during this period, namely by investing in the largest and most expensive growth stocks. Other factors were only effective to the extent that they provided implicit exposure to the same large growth stocks. Smaller stock portfolios underperformed across the board. Thus, there were numerous ways to fail during the 2018-2020 period but, essentially, only one way to succeed. Comparing the quant crisis with previous major drawdowns of the value factor, the author finds that these other periods are better characterized as momentum factor rallies with collateral damage for the value factor. Moreover, smaller stocks typically still offered possibilities for outperformance. The author concludes that the 2018-2020 quant crisis posed an exceptional challenge to quantitative managers due to a rare combination of circumstances.

TOPICS

Security Analysis and Valuation, factor-based models, statistical methods, financial crises and financial market history*

Quantitative managers following multifactor strategies have generally underperformed severely since the middle of 2018. This drawdown is clearly visible in Exhibit 1, which shows average factor performance in global developed equity markets since 2010. The graph is constructed by computing every month the equally weighted average return of the standard academic factors: size (SMB), value (HML), investment (CMA), profitability (RMW), and momentum (WML). Without the momentum factor, which is not formally included in the five-factor model of Fama and French (2015), factors even experienced an entire lost decade, consistent with the observations of Blitz (2020).

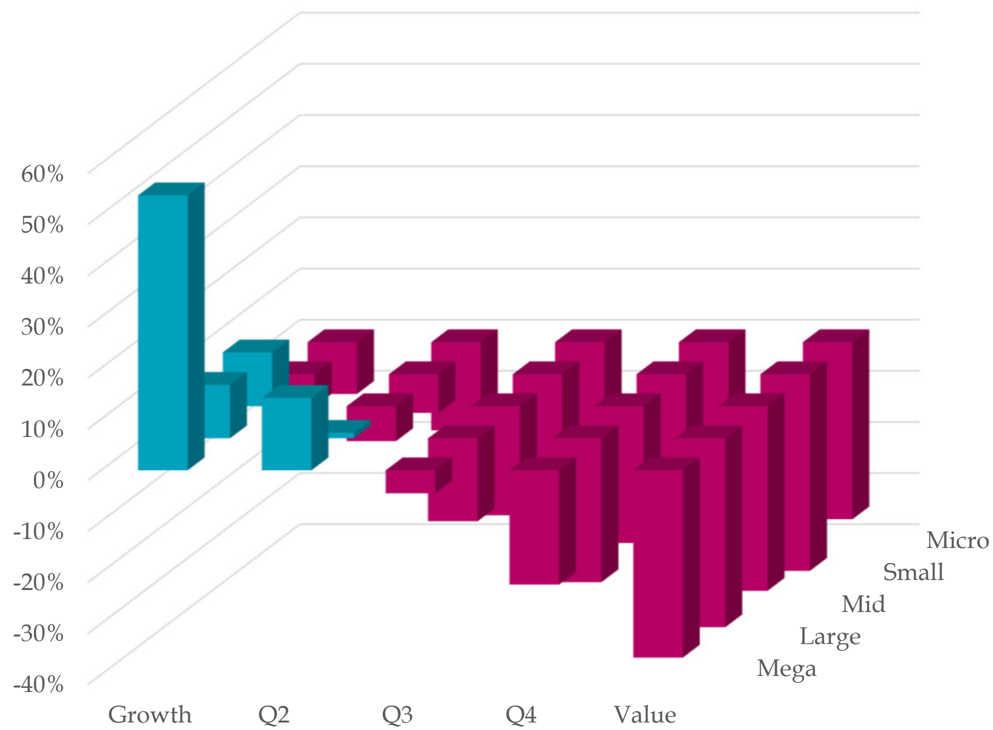
This article takes an in-depth look at the multiyear drawdown of equity factors that started in 2018. As such, it is related to the asset pricing literature, but it differs by

*All articles are now categorized by topics and subtopics. View at PM-Research.com.

Challenges: Lessons Learned from the recent Quant Crisis

- Let's zoom in on 5x5 size/value sorted portfolios during the crisis period
- The largest growth stocks had a massive (>50%) outperformance (FANMAG, Tesla, etc.)
- Slightly less large or slightly less expensive growth stocks also outperformed
- Everything else underperformed

Market-relative performance of 5x5 size/value sorted portfolios in global developed markets during the Quant Crisis



ROBECO

Challenges: Lessons Learned from the recent Quant Crisis

- Bloodbath outside the mega-cap segment: 85% of 5x5 sorted portfolios underperform, and 70% even double-digit
- Small pockets of outperformance for mega-caps with the most aggressive investment, highest profitability, and highest momentum

Performance of 5x5 sorted portfolios in developed markets, June 2018 to August 2020

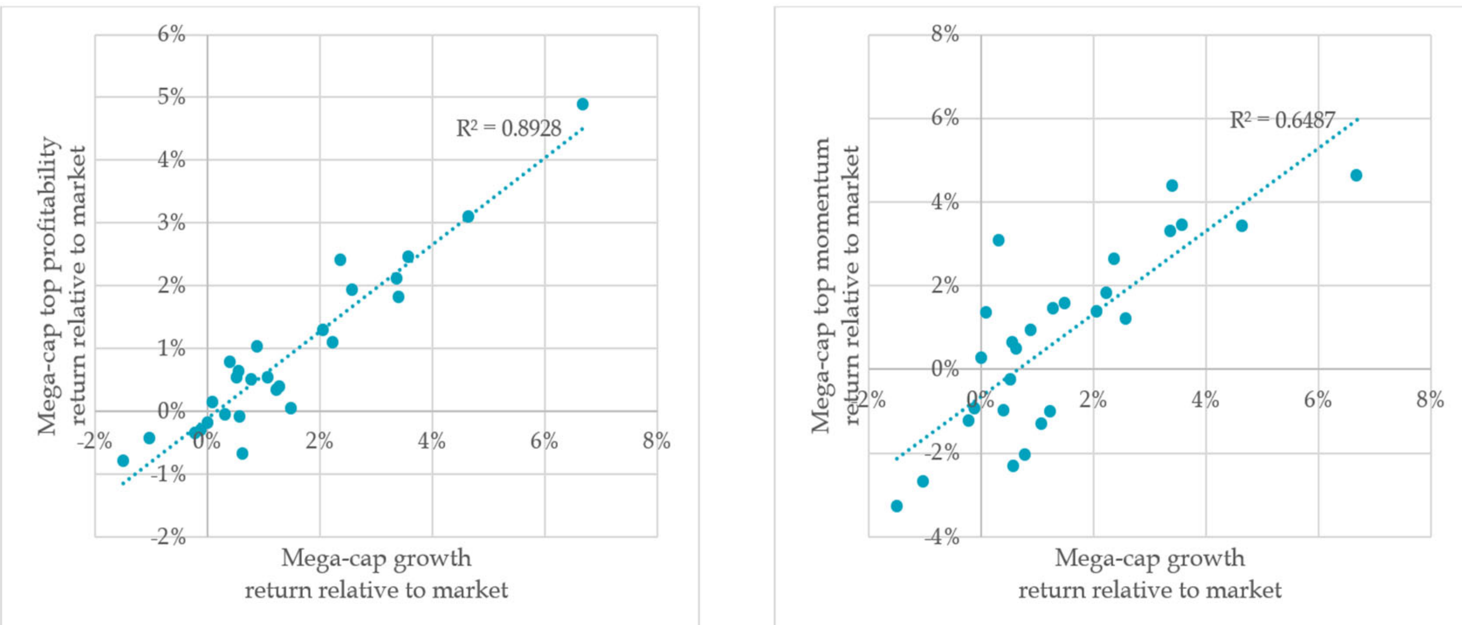
	Value					Investment				
	Growth	Q2	Q3	Q4	Value	Agg	Q2	Q3	Q4	Cons
Mega	**53.8%**	**14.2%**	-4.5%	**-22.4%**	**-36.6%**	**29.3%**	**14.4%**	1.3%	-9.5%	6.4%
Large	**10.5%**	1.1%	**-16.2%**	**-28.2%**	**-37.0%**	**13.0%**	**-16.4%**	**-15.3%**	**-27.3%**	**-22.0%**
Mid	**10.5%**	-6.8%	**-21.3%**	**-26.7%**	**-36.1%**	-5.8%	**-18.4%**	**-24.8%**	**-28.3%**	**-26.1%**
Small	-6.3%	-7.5%	**-25.8%**	**-26.9%**	**-38.5%**	**-19.7%**	**-20.9%**	**-22.6%**	**-29.8%**	**-34.6%**
Micro	**-10.1%**	**-17.2%**	**-22.0%**	**-29.1%**	**-34.7%**	**-20.8%**	**-25.7%**	**-28.3%**	**-29.0%**	**-30.7%**

	Profitability					Momentum				
	Weak	Q2	Q3	Q4	Robust	Losers	Q2	Q3	Q4	Winners
Mega	**-17.1%**	-7.9%	-7.1%	**9.8%**	**30.7%**	**-18.8%**	-3.8%	4.3%	6.1%	**26.0%**
Large	-7.9%	**-23.0%**	**-17.3%**	**-12.8%**	-9.6%	**-27.0%**	**-20.6%**	**-13.6%**	-6.2%	-3.3%
Mid	**-18.2%**	**-22.6%**	**-17.2%**	**-20.0%**	**-19.1%**	**-25.5%**	**-25.5%**	**-22.3%**	**-14.0%**	-7.2%
Small	**-25.7%**	**-25.2%**	**-28.3%**	**-21.8%**	**-22.9%**	**-30.6%**	**-24.3%**	**-24.2%**	**-19.8%**	**-13.0%**
Micro	**-27.6%**	**-28.1%**	**-28.8%**	**-24.6%**	**-17.9%**	**-35.9%**	**-26.5%**	**-24.0%**	**-22.2%**	-4.9%

Challenges: Lessons Learned from the recent Quant Crisis

- Bloodbath outside the mega-cap segment: 85% of 5x5 sorted portfolios underperform, and 70% even double-digit
- Small pockets of outperformance for mega-caps with the most aggressive investment, highest profitability, and highest momentum
- Mega profitability and mega momentum were also mega growth (light) in disguise!

Co-movement between mega-cap profitability, mega-cap momentum, and mega-cap growth during the Quant Crisis



ROBECO

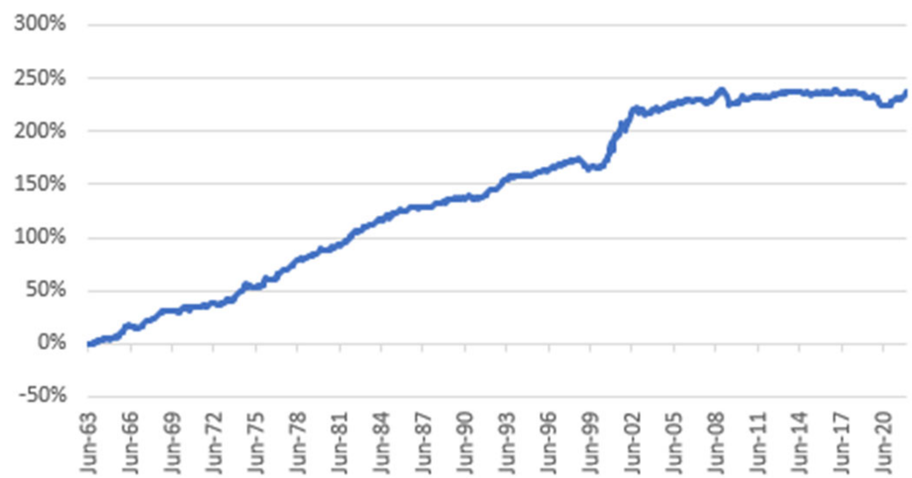
From Challenges to Questions

- During the recent 18-20 crisis, there were many ways to fail, but essentially only one way to succeed—where was the diversification benefit?!

- And if we zoom out of the crisis period, it is quite a clear pattern that generic factors seem to decay over time (e.g. in the U.S.)

- Serious questions for quant:
  - How to find uncorrelated new alpha sources?
  - How to squeeze more out of the common factors?
  - How to leverage on alternative data and machine learning to achieve these goals?

Performance of a 1/N portfolio consisting of the size (SMB), value (HML), investment (CMA), profitability (RMW), and momentum (WML) factors in the US market



ROBECO

Alternative Data

Alternative Data

Common interpretation

Alternative Data

- Not readily available
- Non-standard
- Usually very large in scale
- High potential benefits?

Market + Fundamentals → THOMSON REUTERS, STANDARD & POOR'S, Bloomberg

Web-scraped + Holdings based → DOW JONES NEWSWIRES, IHS Markit

Satellite imagery + Geo-location → GAMAYA, ADVAN Research through Technology

Complexity + Opportunity

Alternative Data
Example of screening funnel

Alternative Data

Alternative data challenges

Permanency risk	→	Need to assess data collection best practices
Less history & coverage	→	Need economic rationale and advanced techniques
High turnover	→	Faster signal decay requires smarter trading
Higher noise	→	Non-numerical information requires skills to extract information
Integration & mapping	→	Extra efforts to make data executable in our system

ROBECO

Alternative Data

Evaluation of alternative data providers

Economic rationale	Stand-alone performance	Value-added	Trading
Robustness across geographic regions or universe segments combined with economic rationale	Evidence of stand-alone performance and robustness to signal construction choices	Cross-validated performance needs to add value on top of existing model factors	The signal should have the potential of surviving trading costs or scalability

Alternative Data: News sentiment signals

News sentiment

- Text-derived news sentiment signals have predictive power for future stock returns
- The signals are often positively correlated with momentum, but still offering distinct source of alpha
- The example here illustrates how news sentiment can be a better leading indicator than traditional metrics
- We observe no long-term reversal in performance, suggesting that this mainly captures an underreaction effect

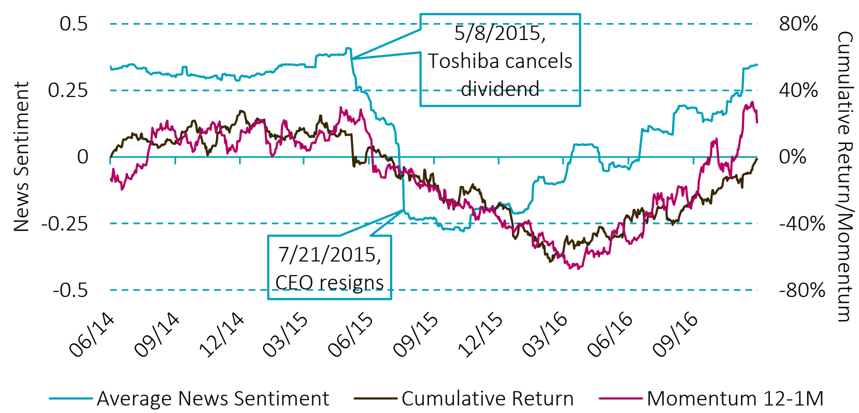
How to build robust news sentiment signals?


TOSHIBA CHIEF EXECUTIVE RESIGNS OVER SCANDAL

Toshiba's chief executive and president Hisao Tanaka has resigned after the company said it had overstated its profits for the past six years.

He will be succeeded by chairman Masashi Muromachi, with vice-chairman Norio Sasak also stepping down.

On Monday, an independent panel appointed by Toshiba said the firm had overstated its operating profit by a total of 151.8bn yen ($1.22bn, £780m) . The overstatement was roughly triple an initial estimate by Toshiba.



ROBECO

Alternative Data: News sentiment signals

News sentiment adds value on top of conventional price momentum

- News sentiment performs relatively better when generic price momentum is weak
- News sentiment can predict stock returns beyond other known characteristics, including price momentum

Regression analysis of stock returns on news sentiment and other characteristics 2001-2018

Developed Markets

	Intercept	Beta	Size	Book-to-Price	Mom 12-1M	News
mean	1.16	-0.23	-0.07	0.15	0.20	0.35
t-stat	(3.23)	(-0.81)	(-2.32)	(1.83)	(0.66)	(3.20)

Emerging Markets

	Intercept	Beta	Size	Book-to-Price	Mom 12-1M	News
mean	0.98	-0.08	0.01	0.28	0.30	0.14
t-stat	(1.99)	(-0.61)	(0.11)	(4.07)	(2.85)	(3.78)


ROBECO
The Investment Engineers

Quantitative Research
Integrating news sentiment in quant equity strategies

- New signal added to Robeco's Quant Equity momentum factor
- Improvement builds on Robeco's expertise in big data analysis
- News sentiment adds value on top of conventional price momentum

For almost two decades, Robeco has been managing a range of quant equity strategies, which aim to outperform markets using factors, among which Momentum. To harvest factor premiums, we apply a strict and disciplined process based on proven and transparent techniques. Yet we are also constantly investigating potential improvements for our strategies involving innovative techniques or alternative data sources.

Based on our research, we recently decided to enhance the Robeco momentum factor with the inclusion of a news sentiment signal. In this note, we provide some background regarding the addition of this new signal.

Article
For professional investors
July 2019
Thom Marchesini & Laurens Swinkels

Turning news articles into quantitative data

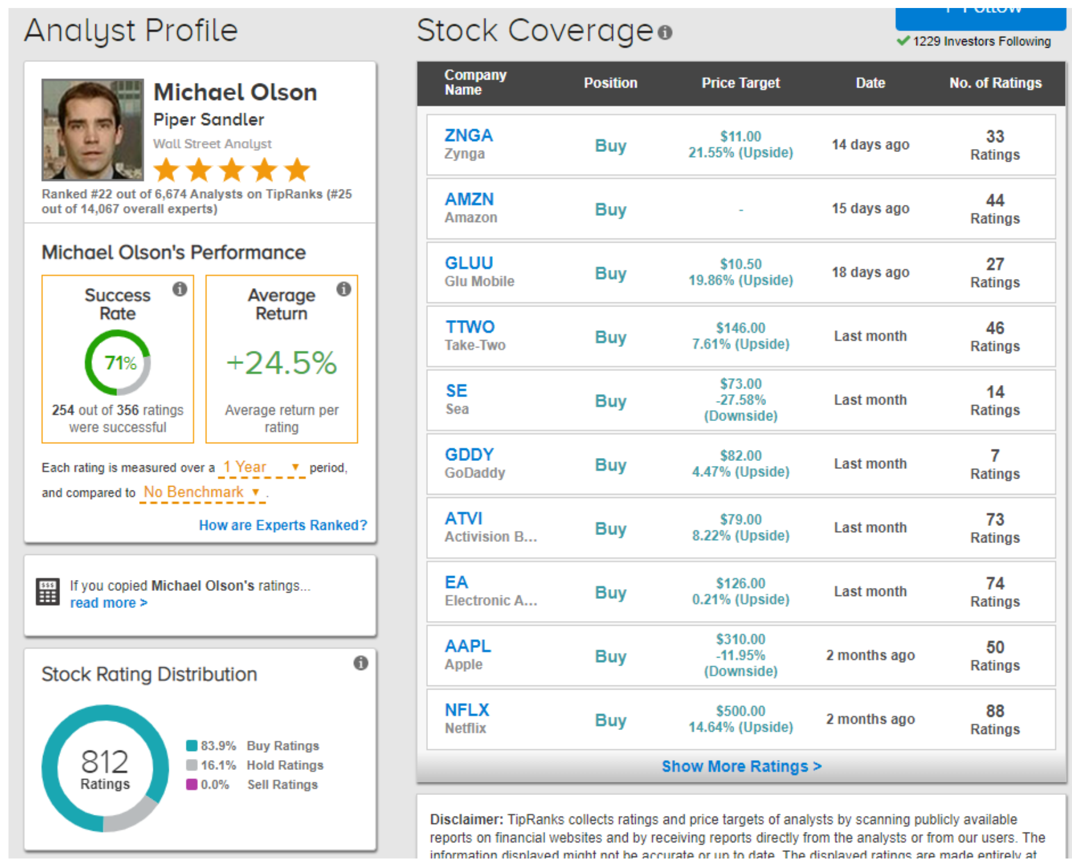
The recent advances in text analysis allow for the information contained in news articles to be turned into quantitative data, that can be used when researching financial markets. Tetlock (2007) was one of the first to use a sentiment signal, detected in the well known "Abreast of the Market" column in the Wall Street Journal, to predict downward market movements the following trading day. He used one of the simplest natural language processing methods called the 'bag of words' to determine the sentiment of the newspaper column.

Source: Robeco Quant Equity Research. Summary statistics of monthly Fama-MacBeth (1973) regressions of stock returns on news sentiment and other firm characteristics over the period January 2001 to December 2018. T-statistics are based on Newey-West standard errors incorporating 12 months lags. For more information see Thom Marchesini & Laurens Swinkels (2019), "Integrating news sentiment in quant equity strategies", Robeco White paper.

Alternative Data: Peer-group trend signal

Based on the complete map of analysts’ connectivity

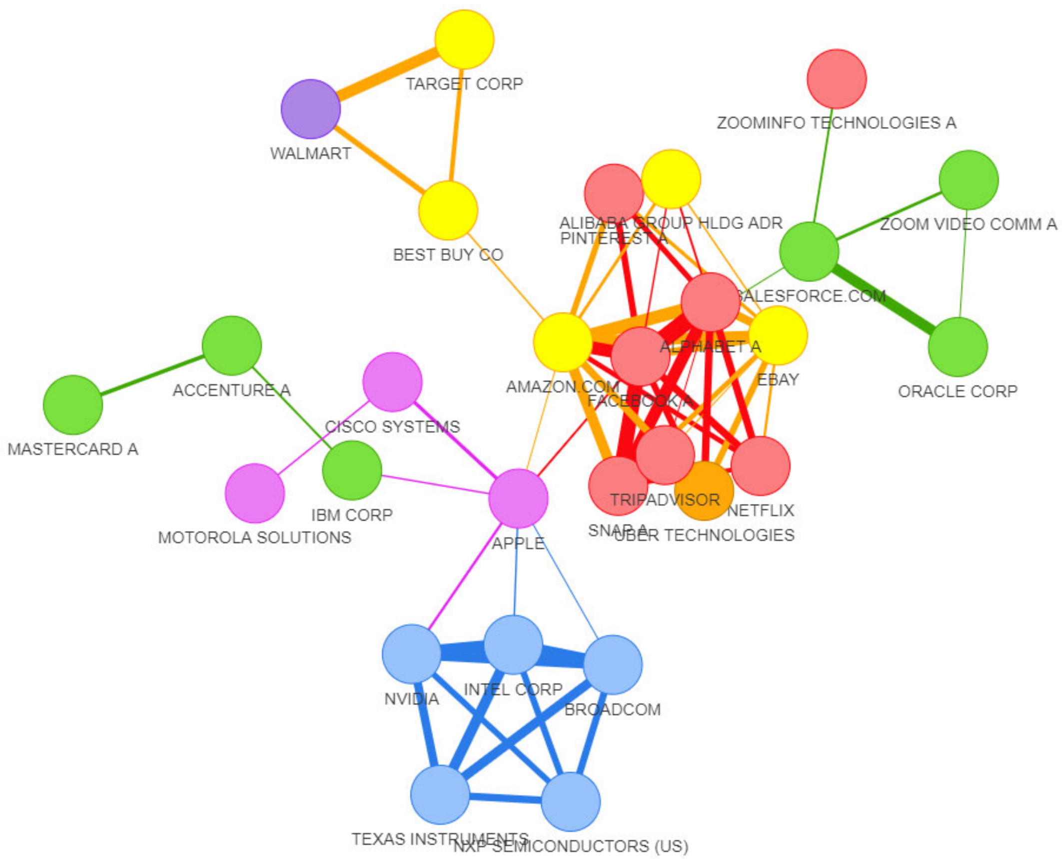
- Peer-group trend is a proven signal capable of capturing short-term outperformance
- These of signals invest in stocks whose peers have recently outperformed, expecting the trend to continue
- The common definition of peer is sector or industry-based
- We identify the alternative peer group for each individual stock, based on its shared analysts’ coverage



Example for illustration’s purpose.

Alternative Data: Peer-group trend signal

Based on the complete map of analysts' connectivity



- We continuously map the connectivity of all stocks via the shared coverage based on > +100K analysts
- Stocks from different sectors and industries are likely to be classified in one peer group
- Results show that our self-defined peer-group trend signal has a strong predictive power over short-term outperformance

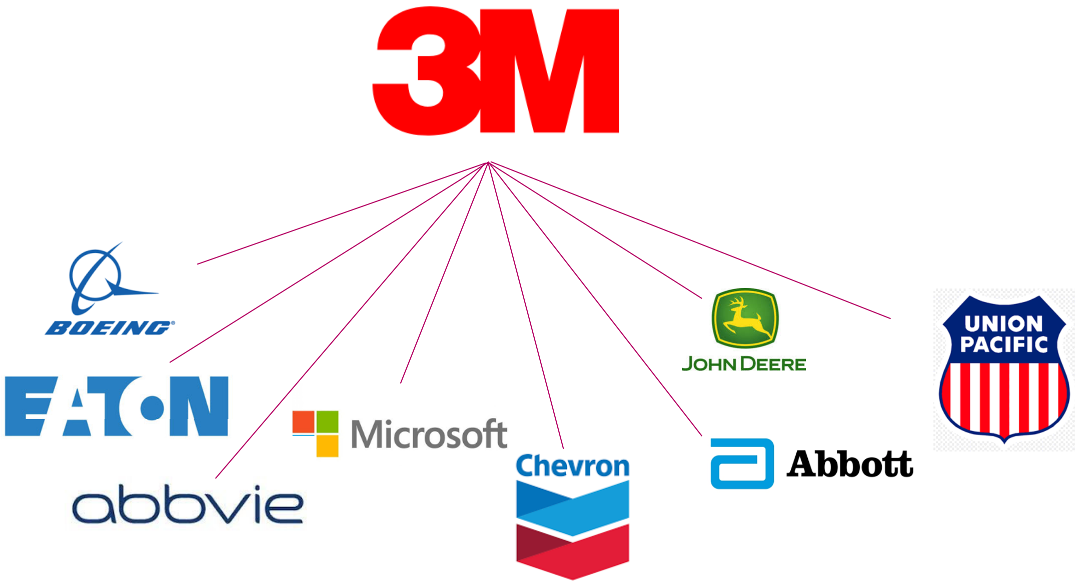
Example for illustration's purpose. Stocks from different sectors are presented in different colors.

ROBECO

Dismissed idea: The effect of board connections and profiles

Do companies with central boards of directors outperform?

DIRECTORNAME	DIRECTOR_ID	COMPANY	ISIN	REPORTDATE
Amy Hood	**1130760**	**3M**	**US88579Y1010**	**20171201**
Amy Hood	1130760	MICROSOFT	US5949181045	20170601
Inge Thulin	**534445**	**3M**	**US88579Y1010**	**20171201**
Inge Thulin	534445	CHEVRON	US1667641005	20171201
Vance Coffman	**33719**	**3M**	**US88579Y1010**	**20171201**
Vance Coffman	33719	DEERE	US2441991054	20171001
Ed Liddy	**33916**	**3M**	**US88579Y1010**	**20171201**
Ed Liddy	33916	ABBOTT LABS	US0028241000	20171201
Ed Liddy	33916	ABBVIE	US00287Y1091	20171201
Ed Liddy	33916	BOEING	US0970231058	20171201
Greg Page	**66557**	**3M**	**US88579Y1010**	**20171201**
Greg Page	66557	DEERE	US2441991054	20171001
Greg Page	66557	EATON	IE00B8KQN827	20171201
Herb Henkel	**48721**	**3M**	**US88579Y1010**	**20171201**
Dave Dillon	**35928**	**3M**	**US88579Y1010**	**20171201**
Dave Dillon	35928	UNION PACIFIC	US9078181081	20171201



ROBECO

Dismissed idea: Patent information

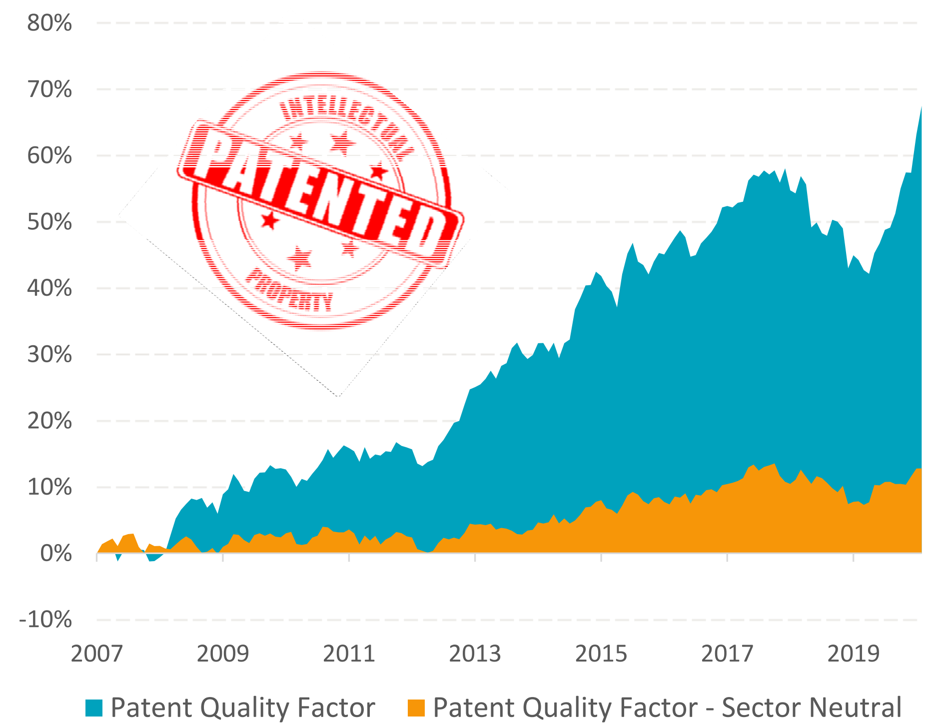
Do companies with higher patent quality outperform?

- Literature suggests that simply counting the quantity of patents is a poor measure of innovation
- Patent quality is a better metric, (usually) measured with the number of citations that patent receives
- A citations-based patent quality measure can be enhanced by taking other information into account, such as market attractiveness and legal aspects

Main findings

- Alpha generated from the patent related data predominantly comes from the allocation effect, and not from the selection within sectors
- Other knowledge capital measures seem to be better predictors of the future cross-sectional excess returns than patents
- Patent-related features do not add additional predictability in the non-linear structure either

Cumulative CAPM Alpha

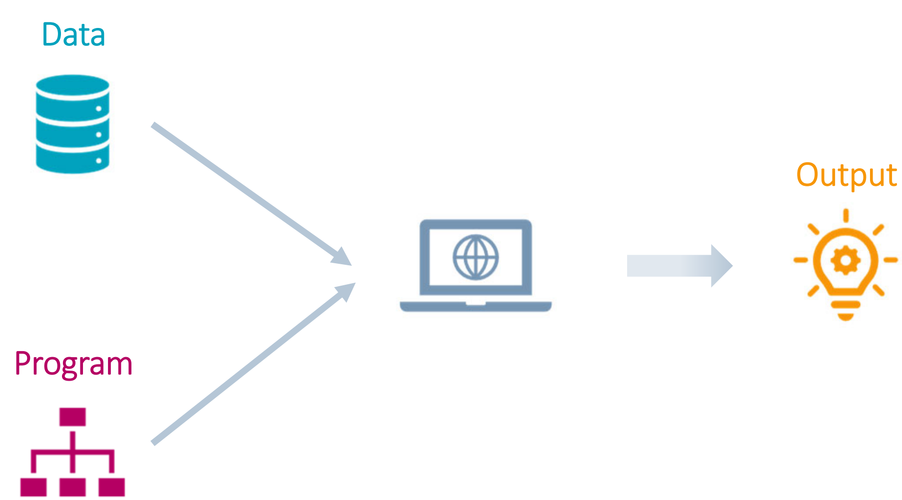


Source: Robeco Research. For illustrative purposes only.

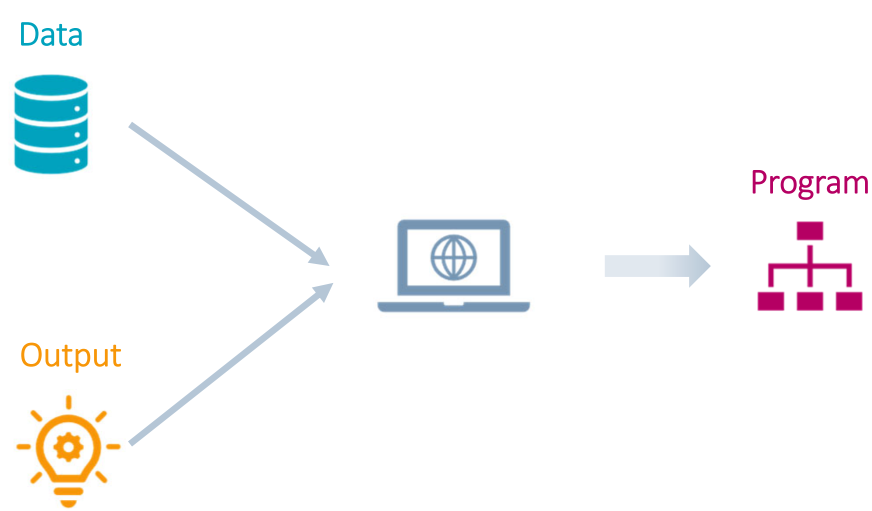
Machine Learning

What is machine learning?

Traditional programming



Machine Learning



Types of problems that can be solved with machine learning

Classification

- Predicting winner of election
- Detecting spam emails
- Predicting if tumor is malignant

Regression

- Predicting level of income
- Predicting price of a house
- Predicting stock return

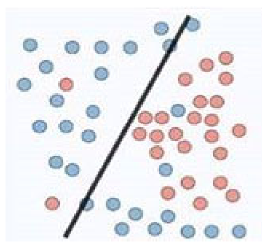
Clustering

- Which viewers like same movie?
- Which ad will clients click on?
- Which size of clothes to design?

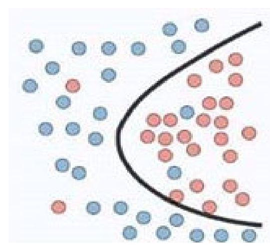
Machine Learning relaxes the functional form imposed by more parametric models

Machine Learning delegates the task of figuring out dependencies between variables to algorithms, with very few assumptions.

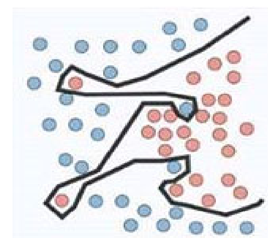
This sounds fantastic but can also be a curse in disguise. A lot of time should be spent on getting the "right fit"



Linear model might be too simple to explain the variance in the data.



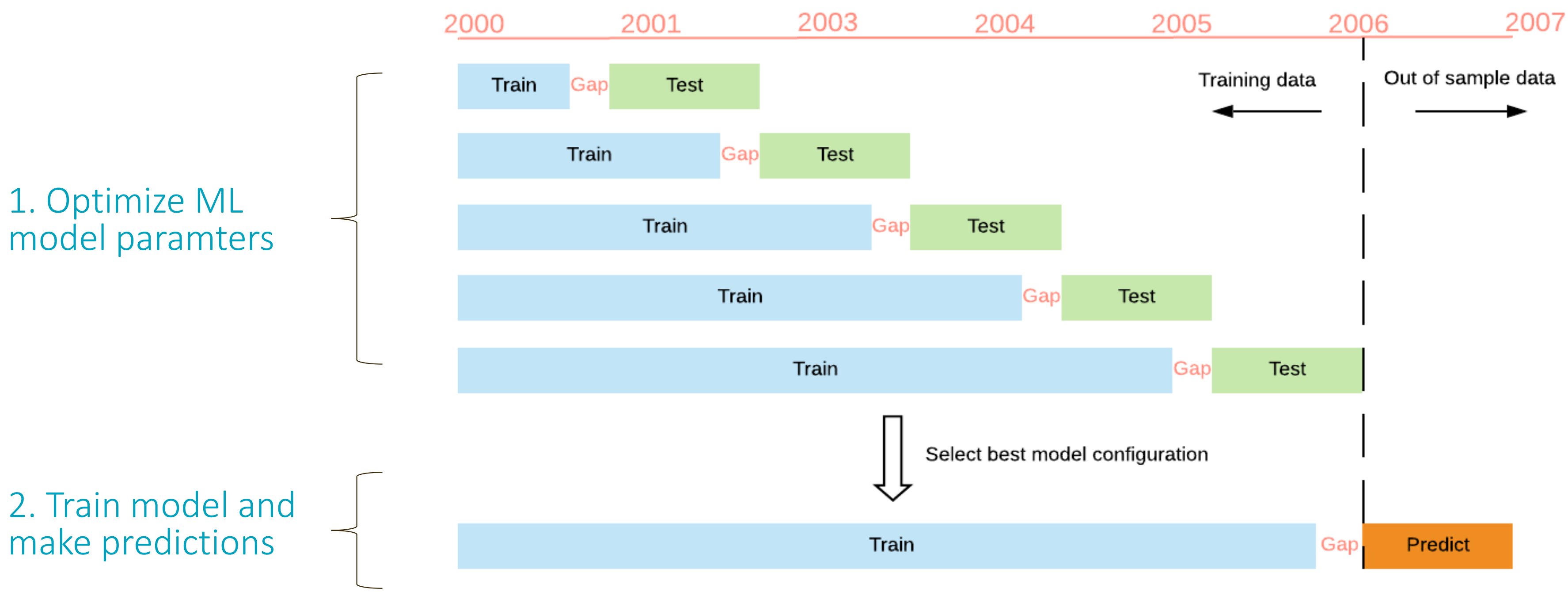
Non-linear models might be able to find a more meaningful relationship.



When applied incorrectly, the model will fit on noise and have low predictive performance on new data.

Cross-validation for timeseries

Time series cross-validation



- This is a fully-data driven process and uses only data available when making the prediction
- Gaps included for prudency and prevention of data leakage for variables that are static for some months

Stock selection alpha with machine learning: Evidence in the literature
ML using only past returns

Krauss, Do, and Huck (2016): Machine learning for statistical arbitrage on the S&P 500

Models

> Deep neural networks (DNN), gradient-boosted-trees (GBT), random forests (RAF), and a combination (ENS)

Classification problem

> Generated the probability forecast of a stock to outperform the general market (daily one-day-ahead signal)

Trading strategy

> Long top k stocks with the highest probability to outperform and short k stocks with the lowest probability

Main conclusions

> ENS produces out-of-sample returns exceeding 0.45 percent per day for $k = 10$, prior to transaction costs

> However, efficacy is declining in recent years

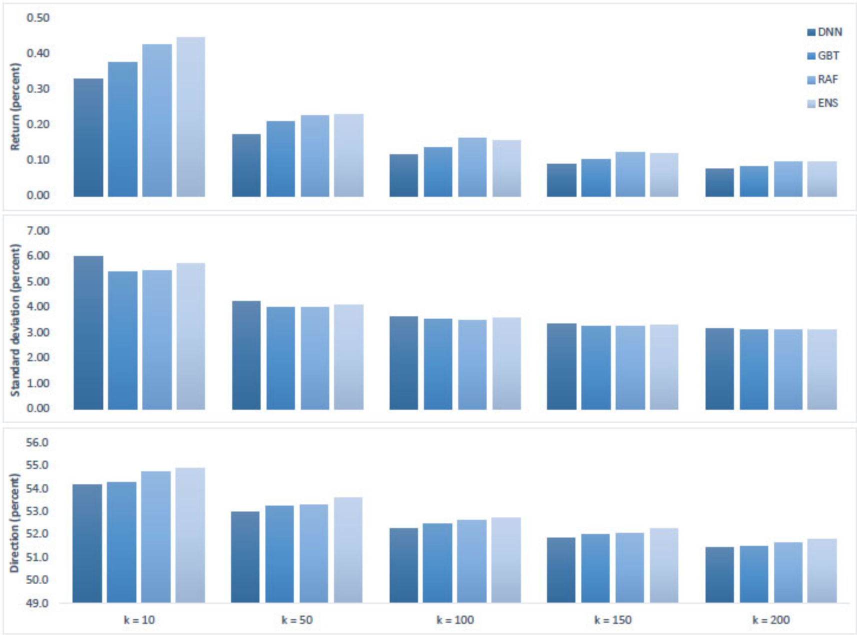


Figure 1: Daily performance metrics for long-short portfolios of different sizes: Mean return, standard deviation, and directional accuracy from December 1992 until October 2015.

ROBECO

Stock selection alpha with machine learning: Evidence in the literature

ML using only past returns

Murray, Xiao, and Xia (2020): " Charting by machines", inspired by classic technical analysis

Models

> Feed-forward neural network (FNN), convolutional neural network (CNN), long-short term memory (LSTM), and convolutional neural network with long-short term memory (CNNLSTM)

Regression problem

> Predict excess stock return in month t (and its transformations)

Trading strategy

> Long top decile and short bottom decile portfolio

Main conclusions

> ML methods offer added value on top of the implicit exposures to the classic return-based signals such as short-term reversal, medium-term momentum, and seasonal effects

> Predictive power persists for about 4 months

Table 3: Portfolio Analysis

Value	$MLER\ 1$	$MLER\ 10$	$MLER\ 10-1$
Excess Return	−0.13	0.93	1.06
	(−0.50)	(5.00)	(5.38)
α^{CAPM}	−0.80	0.38	1.18
	(−6.20)	(3.86)	(6.17)
α^{FF}	−0.86	0.36	1.22
	(−7.80)	(3.80)	(7.00)
α^{FFC}	−0.58	0.19	0.78
	(−6.21)	(2.11)	(5.03)
α^{FFCLIQ}	−0.58	0.21	0.78
	(−5.89)	(2.16)	(4.84)
α^{FF5}	−0.68	0.31	0.99
	(−6.27)	(3.56)	(6.27)
α^{Q}	−0.50	0.21	0.71
	(−4.27)	(1.89)	(3.66)

Stock selection alpha with machine learning: Evidence in the literature

ML using many factor characteristics as input

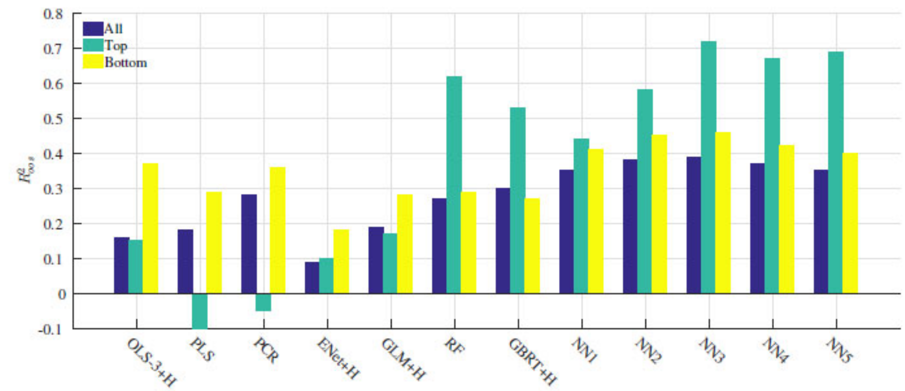
Studies reporting high Sharpe ratios

- Most studies that use ML for predicting stock returns use many factor characteristics (typically over 50) as input
- Studies such as Gu, Kelly, and Xiu (2020) or Rasekhschaffe and Jones (2019) claim that the ML strategies achieve much higher Sharpe ratios and alphas than comparable linear strategies

Skeptical studies

- Overfitting concern due to high degrees of freedom of ML approaches and rise of big data (Novy-Marx, 2015, Martin and Nagel, 2019)
- Economic gains in portfolio backtests depends critically on the ability to take risk and implement trades efficiently (Leung et al., 2021)
- Deep learning signals extract profitability from difficult-to-arbitrage stocks and during high limits-to-arbitrage market states; in particular, microcaps, distressed stocks, or episodes of high market volatility (Avramov, Cheng, and Metzker, 2019)

Gu, Kelly, and Xiu (2020)



Note: In this table, we report monthly R^2_{oos} for the entire panel of stocks using OLS with all variables (OLS), OLS using only size, book-to-market, and momentum (OLS-3), PLS, PCR, elastic net (ENet), generalize linear model (GLM), random forest (RF), gradient boosted regression trees (GBRT), and neural networks with one to five layers (NN1–NN5). "+H" indicates the use of Huber loss instead of the l_2 loss. We also report these R^2_{oos} within subsamples that include only the top 1,000 stocks or bottom 1,000 stocks by market value. The lower panel provides a visual comparison of the R^2_{oos} statistics in the table (omitting OLS due to its large negative values).

ROBECO

Stock selection alpha with machine learning: Evidence in the literature

ML for enhancing traditional factors

- Bew et al. (2019) use ML to extract more value from analysts' recommendations, using only analyst data as input
- Snow (2020) uses ML to predict earnings surprises, using not only earnings data but also past returns and other technical indicators such as trading volumes as input
- Binsbergen, Han, and Lopez-Lira (2021) use ML to create better earnings forecasts than analysts and include fundamental variables, such as growth metrics, and macro-economic variables in their analysis
- Anand et al. (2019) use ML to predict profitability using several dozen fundamental variables as input
- Geertsema and Lu (2021) report strong results for a relative valuation signal based on a decision-tree ML approach

- A caveat with these studies is that better results can be expected the more variables are used which are known to predict future stock returns and future fundamental performance

Attention: Applying machine learning to finance is just different

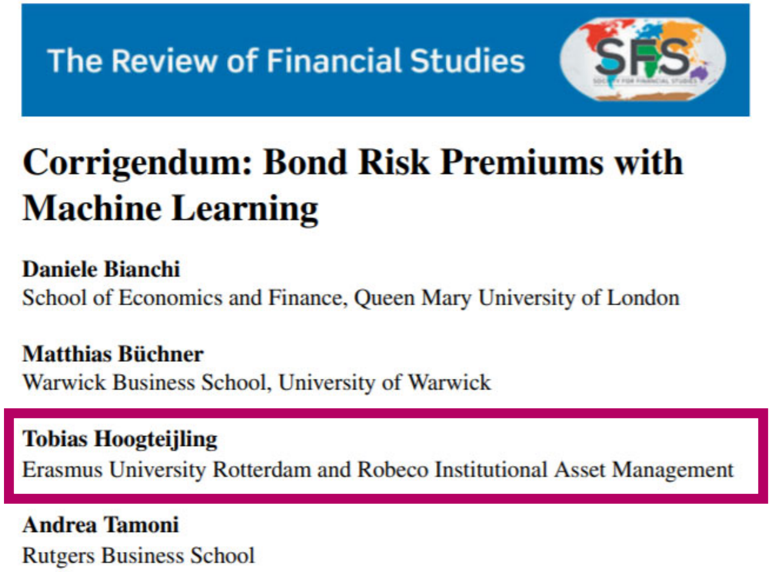
There are successful use cases, characterized by

- High signal-to-noise ratios
- Large data sets

On the other hand, financial markets

- Are notoriously hard to predict
- Have only limited numbers of independent observations
- Require prudency against overfitting and data leakage

→ ML methods do not easily generalize to applications in finance. One must carefully set up the model training process.



The Review of Financial Studies

SFS

Corrigendum: Bond Risk Premiums with Machine Learning

Daniele Bianchi
School of Economics and Finance, Queen Mary University of London

Matthias Büchner
Warwick Business School, University of Warwick

Tobias Hoogteijling
Erasmus University Rotterdam and Robeco Institutional Asset Management

Andrea Tamoni
Rutgers Business School

ROBECO

ML Application 1: Return prediction

Research question

What if you want to predict the future winners?

Applying Machine Learning (ML) to stock selection

Machine is tasked to predict winning stocks over the next week

Tell me the rules to predict **winning stocks over the next week**!

Stock characteristics → Machine

Winning stocks over next week → Machine

Machine → Rules to predict winning stocks

S&P 500 as a common example, given that

- Liquid and large caps → No issues with implementation shortfall and market impact
- Good variable coverage → Premium performance requires premium data
- No time-zone issues → Ensure one builds a viable strategy

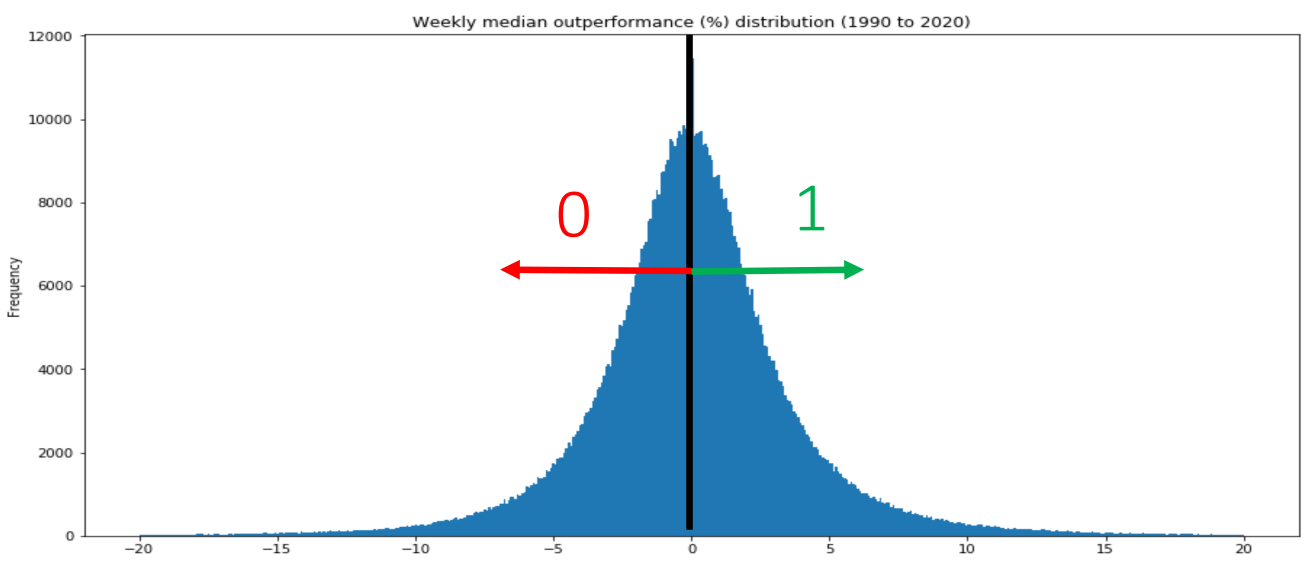
How does the ML trading strategy work?

For training the ML model, one needs to define a forward-looking target

Problem formulation: classification task

> Classification is well suited for tasks with low signal-to-noise ratio and prevents instable gradients during training

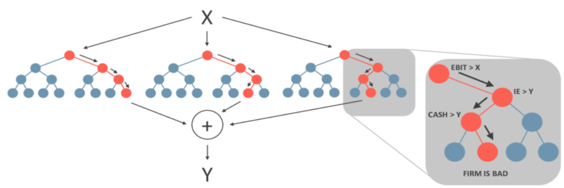
Training target: 1 if over the next week stock return ≥ median stock return, else 0



Source: Robeco. For illustration only.

Model diversification reduces chance of overfitting

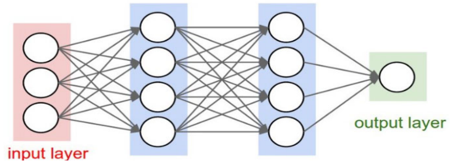
Model 1: Random Forests



...

...

Model N: Neural Network (2-Layer)

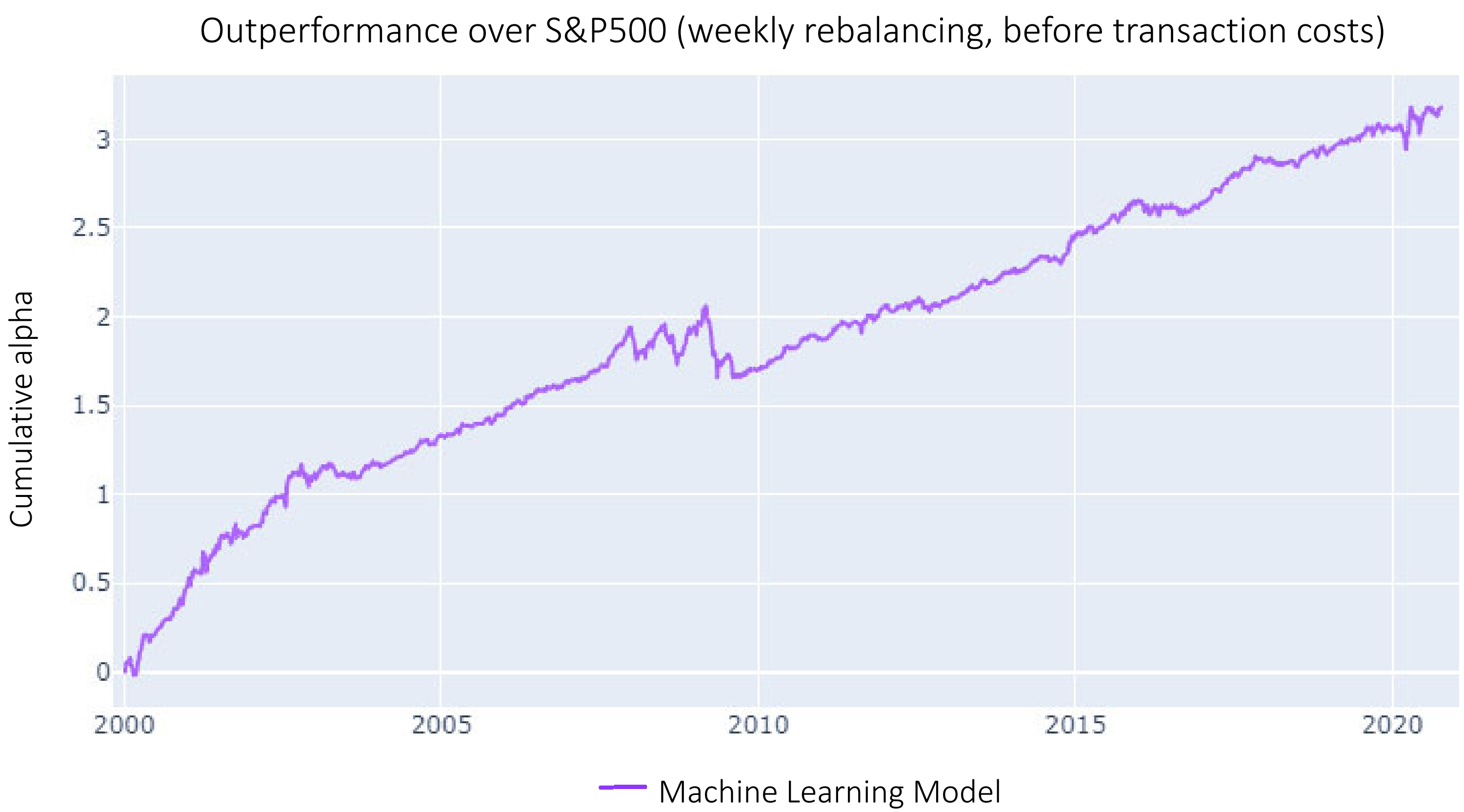


Averaging multiple models reduces risk of wrong prediction

ROBECO

Applying ML to stock selection on S&P 500

ML signal backtest: multiple models making a joint call



Source: Robeco. For illustration only.

ROBECO

What relationships does the ML model capture?
The ML model shows intuitive behavior

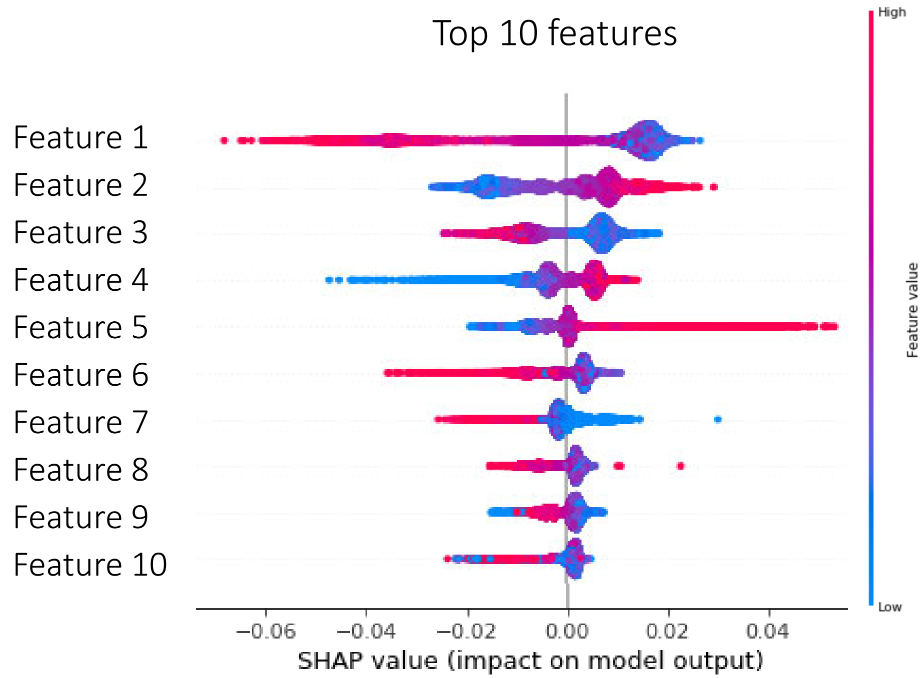
Interpreting Machine Learning predictions

- For each stock, one can compute Shapley (SHAP) values which measure each feature's contribution to the prediction
- An aggregate of absolute Shapley values for each feature gives the overall feature importance

How to read the figure

- **Feature 1**: stocks with high feature values have a lower probability of outperforming next week
- **These effects are non-linear:** low values of Feature 1 do not increase outperformance probability as much

Top 10 features



Source: Robeco. Illustration only. For more information about shapley values, see *A Unified Approach to Interpreting Model Predictions* – Lundberg and Lee, NIPS paper (2017), https://github.com/slundberg/shap.

ROBECO

What relationships does the ML model capture?

The ML model captures academically documented insights

How to read the figure

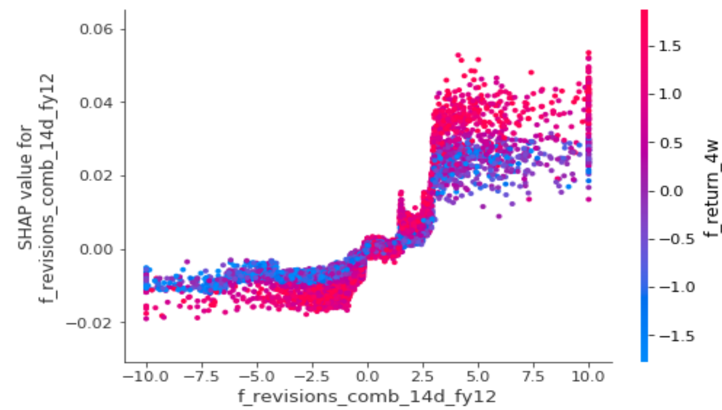
> Y-axis shows if the feature pushes the outperformance probability up or down

> X-axis shows the standardized feature value

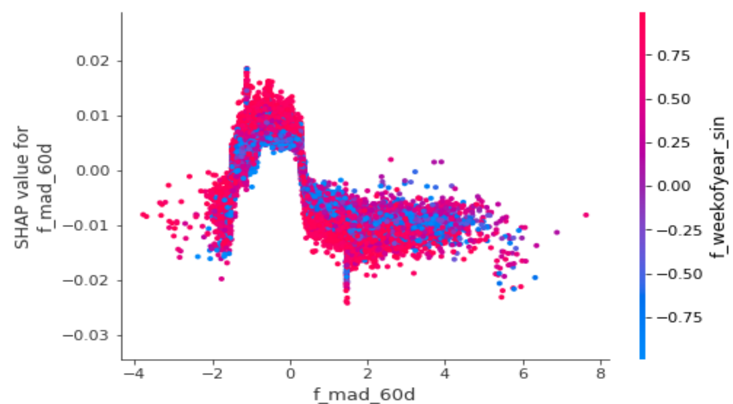
Examples

> **Interaction**: High revisions increases outperformance probability, and even more so if this is paired with high 4w return

> **Non-linearity**: Stocks with an average risk have a higher outperformance probability



Reversal - Revisions interaction[1]



Beta-1 effect[2]

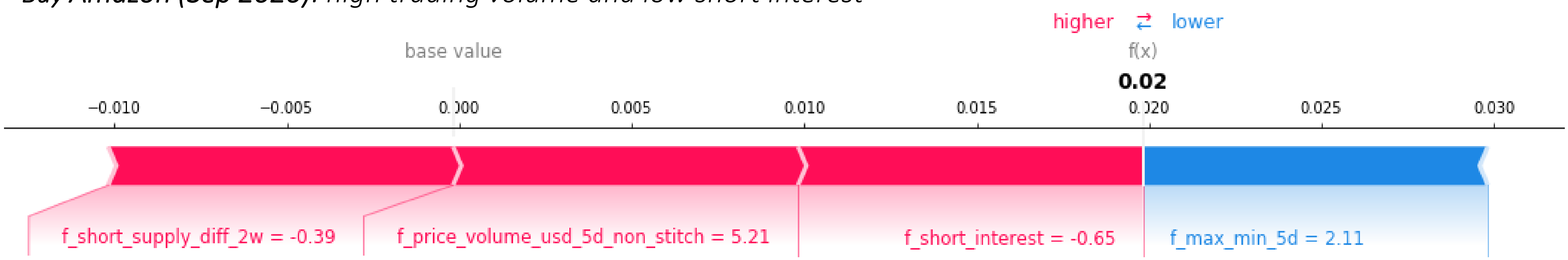
Source: 1. *A Closer Look at the Short-Term Return Reversal* – Da, Liu and Schaumburg (Management Science, 2014)
2. *Low Volatility and Beta 1.0 Portfolios* – Falkenstein (personal blog, 2010)

How does an ML trading strategy work?

For each stock, the model returns a probability it will outperform over the next week

For each stock, the predictions can be explained by commonly used Shapley values

Buy Amazon (Sep 2020)*: high trading volume and low short interest*



Pushes outperf. probability up ⟷ *Pushes outperf. probability down*

Source: Robeco. For illustration only.

One step further: Surgically targeting non-linear relationship beyond linear explanability

- Another application of ML-based return prediction is to search for additional alpha on top of factors
- We have seen interesting practices from the peer, training an ML model to predict the next month's specific returns using style-factor exposures as input
- In this case, the ML model is explicitly directed to capture non-linear relationships that the linear model left behind in its residuals

$$R = Xf + \varepsilon$$

$$\boxed{\varepsilon = G(X)g + \varepsilon'}$$

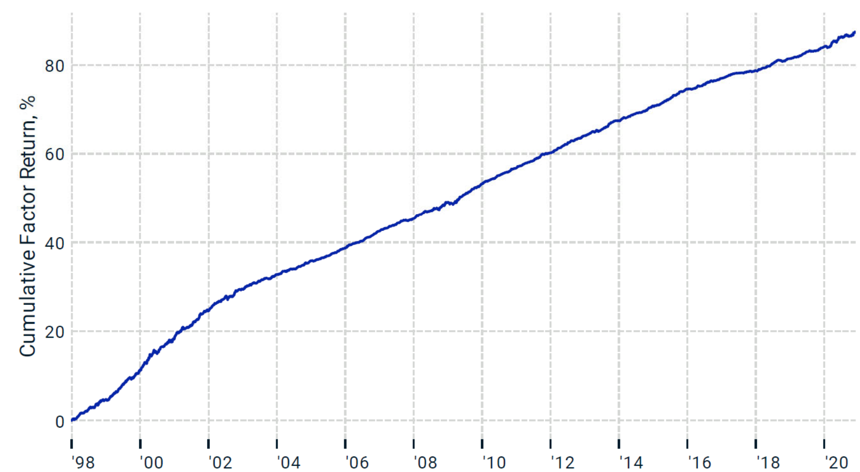
$$R = Xf + G(X)g + \varepsilon'$$

- Such framework allows one to maintain the interpretability of the linear model and factors, while leveraging ML to capture only the non-linear and interaction effects the linear model missed
- The results of this study are remarkably strong (are they too good to be true?)

Exhibit 15: Factor Statistics of GEMTR Styles and ML Factor

Factor	Avg |t|	% |t|>2	Return (%)	Volatility (%)	IR	CV R^2 Gain (bps)	Max Drawdown (%)	VIF	Monthly Auto Correl.
Beta	6.9	81.8	0.02	5.5	0.00	40.8	38.4	3.1	0.98
Momentum	6.4	78.5	3.04	4.3	0.71	37.1	21.6	2.0	0.92
Size	4.8	72.4	-0.49	2.4	-0.21	21.9	22.9	2.6	1.00
Short-Term Reversal	4.2	68.0	2.30	2.4	0.98	16.9	4.0	1.0	0.18
Residual Volatility	4.2	69.5	-1.49	3.0	-0.50	14.8	45.4	2.3	0.97
Liquidity	3.4	59.6	-0.42	2.3	-0.19	9.5	18.2	1.6	0.98
ML Factor	**3.3**	**71.5**	**3.82**	**0.9**	**4.23**	**6.5**	**0.9**	**1.2**	**0.70**
Earnings Yield	2.8	53.8	1.58	2.1	0.77	6.2	7.7	1.9	0.96
Book-to-Price Ratio	2.5	53.8	1.62	1.7	0.97	4.0	5.7	2.2	0.98
Industry Momentum	2.4	49.1	2.32	0.9	2.59	3.6	0.4	1.0	0.53
Analysts Sentiment	2.4	53.8	1.41	1.1	1.32	3.2	3.0	1.0	0.79
Mid Capitalization	2.2	46.2	0.14	1.4	0.10	3.2	4.9	1.3	0.99
Long-Term Reversal	2.3	48.4	1.26	1.5	0.85	3.0	6.4	1.8	0.95

Exhibit 14: Full-Sample Multi-Variate Factor Return of ML Factor



Source: MSCI

ROBECO

ML Application 2: Natural Language Processing (NLP)

Natural language processing (NLP)
What?

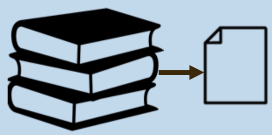
- Automatic manipulation of natural language, like speech and text, by software
- Text to text

I have no time
Je n’ai pas le temps

translation

I have no time
I do not have time

augmentation



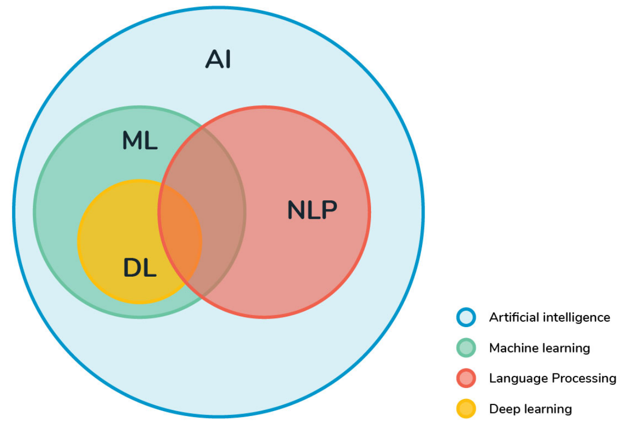
Summarize

- Text to signal

Sentiment/intent

Spam/Fake news

Sensitive comments



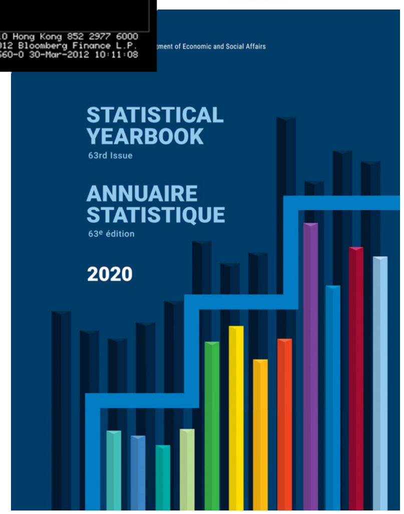
ROBECO

Applying NLP to investments

Linked in

中国证监会
CHINA SECURITIES REGULATORY COMMISSION

U.S. SECURITIES AND EXCHANGE COMMISSION



NLP application: Analyzing company descriptions

- Can we find all the companies related to a hot theme?
- Can we determine the proper peer for valuation comparison?

Example: Adyen

Adyen NV, formerly Adyen BV, is provider of mobile, online and point-of-sale (POS) payment solutions based in the Netherlands. It operates an online platform enabling merchants to accept payments internationally and from all sales channels, such as online shops, mobile payments from applications and Websites, and POS, such as countertops, mobile terminals, tablets and cash registers, among others. The platform covers the entire payment chain, including technical, contractual, reconciliation and settlement processes. The platform is available in the form of ready-to-use payment pages (HPP), application programming interface (API), and client-side encryption solution (EE). The Company's customers include Mango, KLM, Netflix, Superdry, Uber, Groupon and Crocs, among others. It has offices in the Netherlands, the United Kingdom, France, Germany, Belgium, Brazil, China, Australia, Mexico, Singapore, Spain, Sweden and the United States.

NLP application: Words to numbers

Extract meaningful vectors from words (Pre-processing)

- Original text

Adyen NV, formerly Adyen BV, is provider of mobile, online and point-of-sale (POS) payment solutions based in the Netherlands. It operates an online platform enabling merchants to accept payments internationally and from all sales channels, such as online shops, mobile payments from applications and Websites, and POS, such as countertops, mobile terminals, tablets and cash registers, among others

- Removing special characters & Filtering small and stop words

adyen adyen provider mobile online point sale payment solutions based netherlands operates online platform enabling merchants accept payments internationally sales channels online shops mobile payments applications websites countertops mobile terminals tablets cash registers

- Lemmatize: stemming verbs and plurals

adyen adyen provid mobil onlin point sale payment solut base netherland oper onlin platform enabl merchant accept payment intern sale channel onlin shop mobil payment applic websit countertop mobil termin tablet cash regist

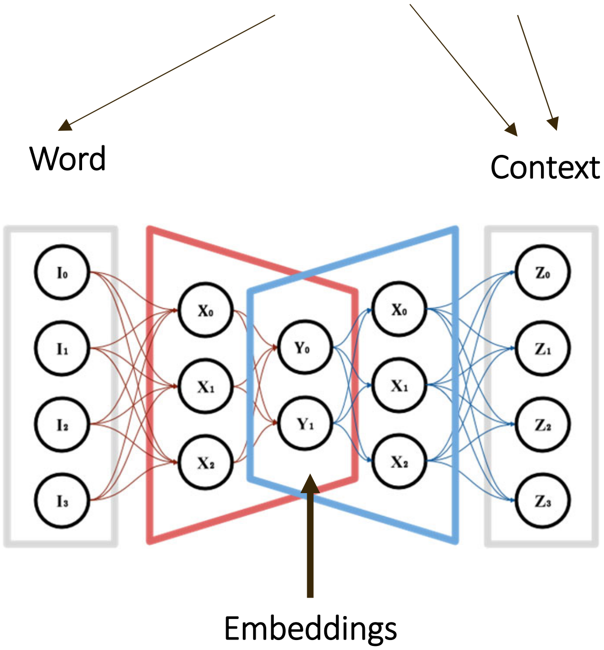
- Tokenize:
  Words to vectors
  Text to list of vectors

```
           Rome Paris                 word V
Rome   = [1,  0,  0,  0,  0,  0,  …,  0]
Paris  = [0,  1,  0,  0,  0,  0,  …,  0]
Italy  = [0,  0,  1,  0,  0,  0,  …,  0]
France = [0,  0,  0,  1,  0,  0,  …,  0]
```

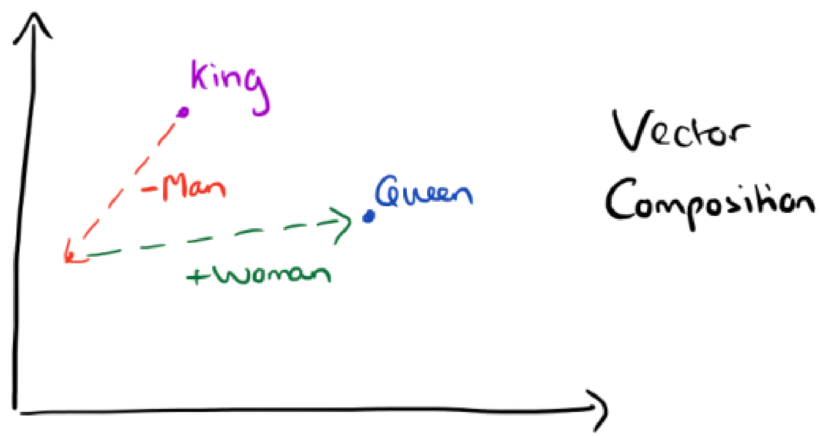

ROBECO

NLP application: Words to numbers
Context learning

Original: Rome is the capital of Italy.
Preprocessed: [rome, capital, italy]



The embeddings have a contextual relationship in the vector space: **Math with words!**



Other example:
paris – france + poland = warsaw.

ROBECO

NLP Application: Applying state-of-art models

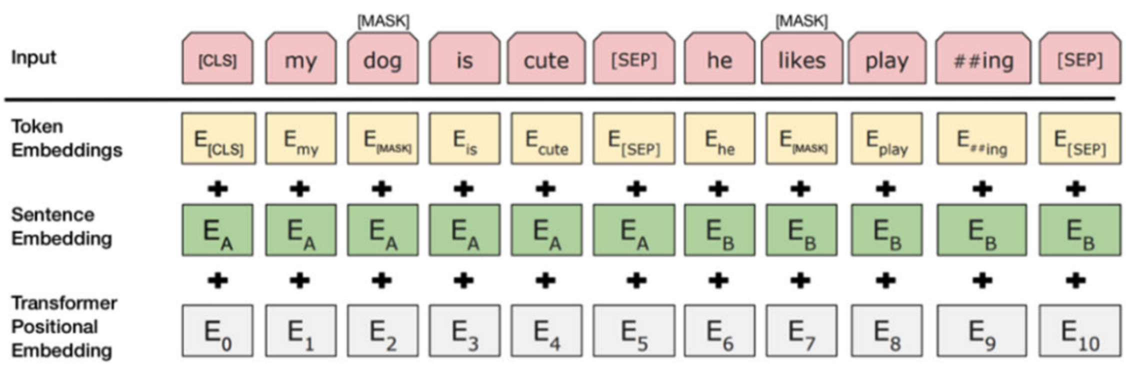
Bert (BiDirectional Encoder Representations from Transformers)

- Math with words -> Math with short texts
- Pre-trained model (Wikipedia + Book corpus, >3 billion words)
- Context aware, meaning of words depend on its surroundings

Dogs that **bark** don't bite

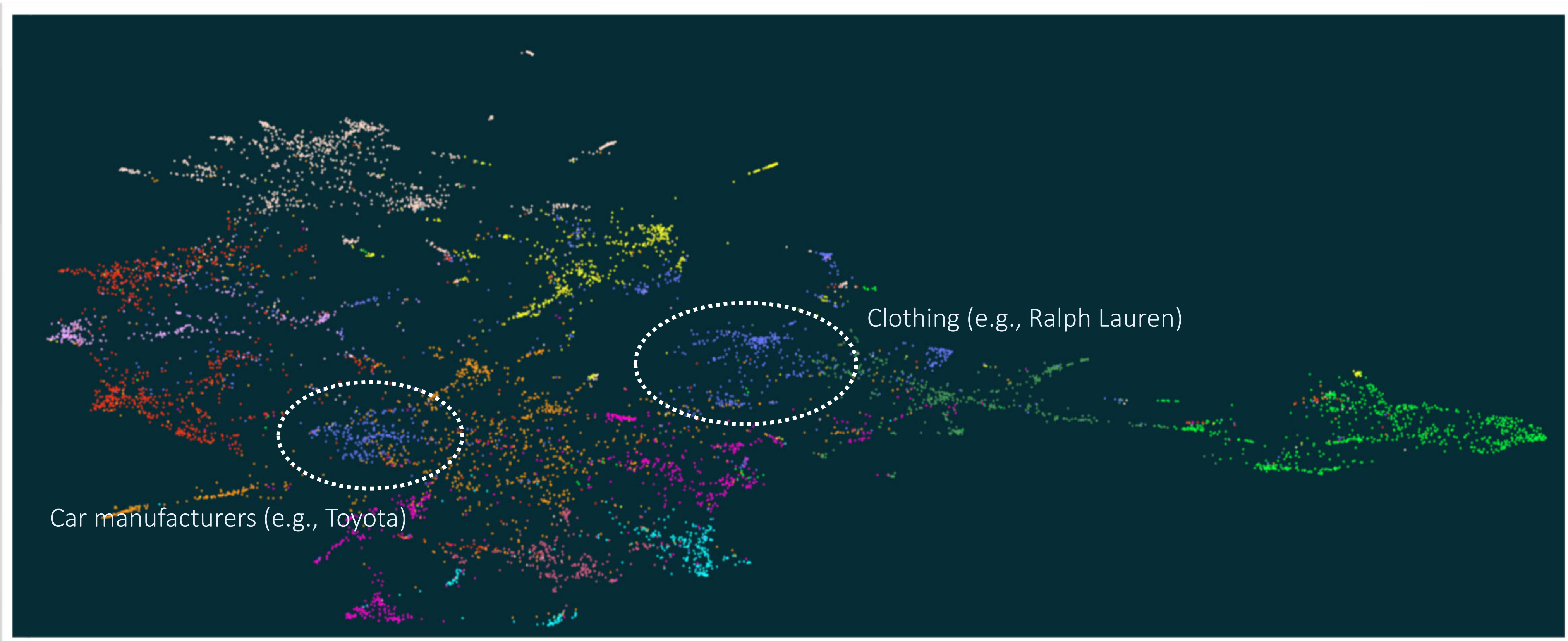
Bark is the outermost layers of stems and roots of woody plants.

- Can we make a list of companies related to a buzzword?



NLP Application: Identify the business connectivity and hidden risks

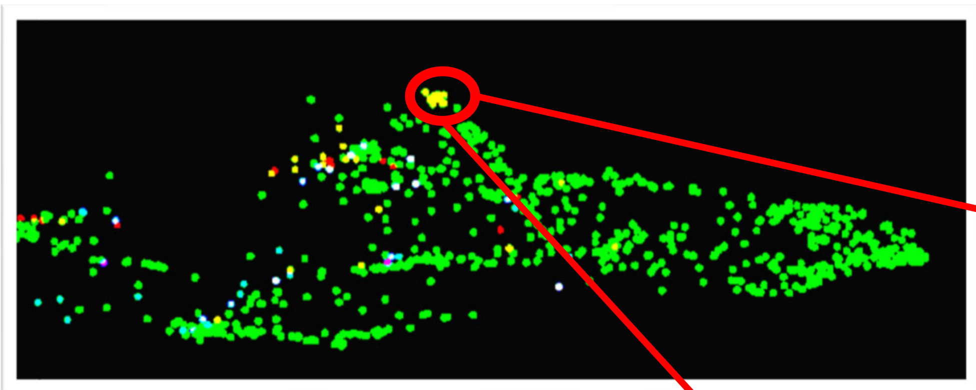
Valuable insights for investors to rethink about clustering than that suggested by GICS



ROBECO

NLP Application: Identify the business connectivity and hidden risks

Meaningful close distance between stocks from different sectors (e.g. HC and REIT)



Name: DIVERSIFIED HEALTHCARE
Country: US
GICS: Real Estate

Description:
Diversified Healthcare Trust, formerly Senior Housing Properties Trust, is a healthcare real estate investment trust (REIT). The Company is focused on healthcare and life sciences located throughout the United States. Its segments include triple net senior living communities that provide short term and long term residential care and other services for residents; managed senior living communities that provide short term and long term residential care and other services

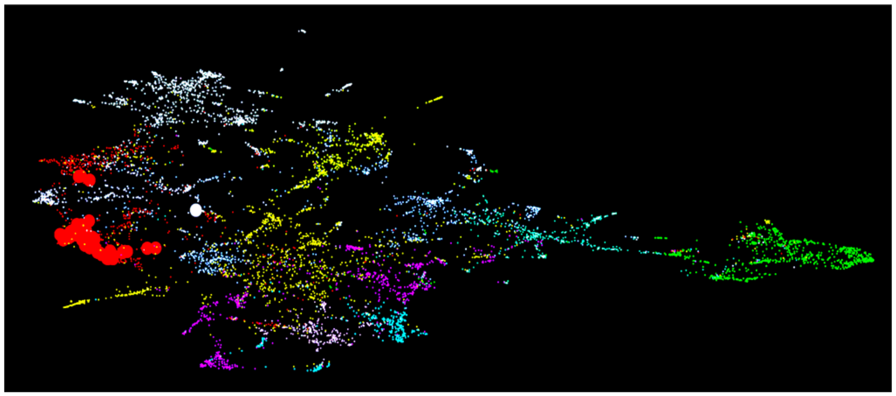
Name: LTC PROPERTIES
Country: US
GICS: Real Estate

Description:
LTC Properties Inc. is a healthcare real estate investment trust (REIT). The Company invests in senior housing and healthcare properties through sale-leaseback transactions, mortgage financing and structured finance solutions, including mezzanine lending. It invests in various properties, including Skilled nursing facilities (SNF), Assisted living facilities (ALF), Independent living facilities (ILF), Memory care facilities (MC) and Range of care facilities (ROC). SNF

NLP Application: Identify the business connectivity and hidden risks

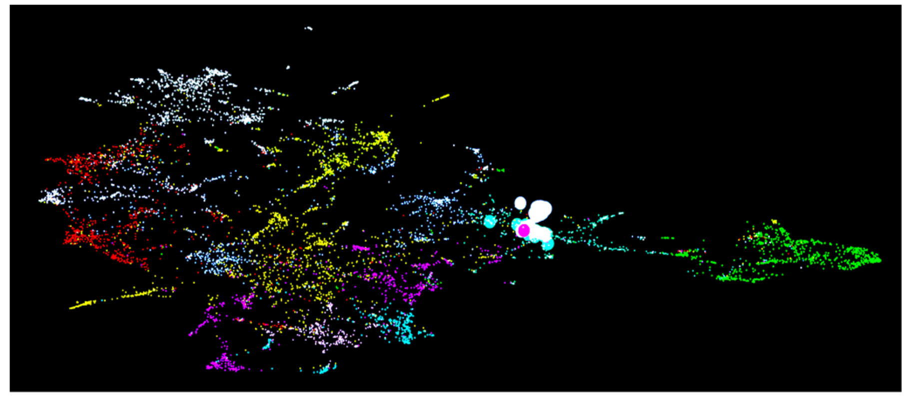
Understand the context—what if there comes a “chip crisis”?

Query: “Making chips”



ALTIUM
APPLIED MATERIALS
SK HYNIX
WINBOND ELECTRONICS CORP
S.O.I.T.E.C.
MICRO-STAR INTERNATIONAL
ONTO INNOVATION
ASPEED TECHNOLOGY

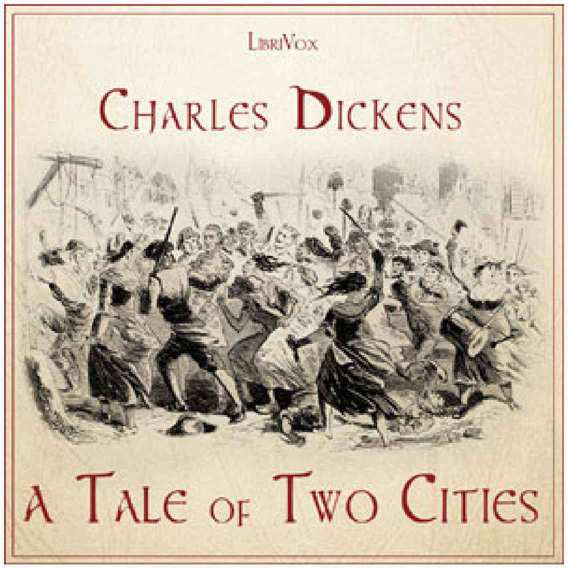
Query: “Eating chips”



DOMINO'S PIZZA ENT
DELIVERY HERO
TEXAS ROADHOUSE A
JACK IN THE BOX
J & J SNACK FOODS CORP
KELLOGG CO
AMREST HOLDINGS
JUST EAT TAKEAWAY.COM

Summary

For Quant Investing.....



It is the best of times, it is the worst of times...

It is the epoch of belief, it is the epoch of incredulity

It is the season of light, it is the season of darkness

It is the spring of hope, it is the winter of despair

We have everything before us, we have nothing before us ...

Keep on doubting, keep on testing!

References

- Anand, V., Brunner, R., Ikegwu, K., and Sougiannis, T., 2019. “Predicting Profitability Using Machine Learning.” SSRN working paper no. 3466478.
- Avramov, D., Cheng, S., and Metzker, L., 2021. “Machine Learning versus Economic Restrictions: Evidence from Stock Return Predictability.” SSRN working paper no. 3450322.
- Bew, D., Harvey, C., Ledford, A., Radnor, S., and Sinclair, A., 2019. “Modelling Analysts’ Recommendations via Bayesian Machine Learning.” Journal of Financial Data Science 1(1), 75-98.
- Binsbergen, J., Han, X., and Lopez-Lira, A., 2021. “Man vs. Machine Learning: The Term Structure of Earnings Expectations and Conditional Biases.” SSRN working paper no. 3625279.
- Geertsma, P., and Lu, H., 2021. “Relative Valuation with Machine Learning.” SSRN working paper no. 3740270.
- Gu, S., Kelly, B., and Xiu, D., 2020. “Empirical Asset Pricing via Machine Learning.” Review of Financial Studies 33(5), 2223-2273.
- Krauss, C., Do, X., and Huck, N., 2016. “Deep Neural Networks, Gradient-Boosted Trees, Random Forests: Statistical Arbitrage on the S&P 500.” FAU Discussion Papers in Economics, No. 03/2016, Friedrich-Alexander-Universität Erlangen-Nürnberg
- Leung, E., Lohre, H., Mischlich, D., Shea, Y., and Stroh, M., 2021. “The Promises and Pitfalls of Machine Learning for Predicting Stock Returns.” Journal of Financial Data Science 3(2), 21-50.
- Martin, I., and Nagel. S., 2019. “Market Efficiency in the Age of Big Data.” SSRN working paper no. 3511296.
- Murray, S., Xiao, H., and Xia, Y., 2020. “Charting by Machines.” Working paper, available at http://www.apjfs.org/resource/global/cafm/2020-14-1.pdf
- Novy-Marx, R., 2015. “Backtesting Strategies Based On Multiple Signals.” SSRN working paper no. 2629935.
- Rasekhschaffe, K., and Jones, R., 2019. “Machine Learning for Stock Selection.” Financial Analysts Journal 75(3), 70-88.
- Snow, D., 2020. “A Surprising Thing: The Application of Machine Learning Ensembles and Signal Theory to Predict Earnings Surprises.” SSRN working paper no. 3420722.

Important information

Important Information

Robeco Institutional Asset Management B.V. has a license as manager of Undertakings for Collective Investment in Transferable Securities (UCITS) and Alternative Investment Funds (AIFs) (“Fund(s)”) from The Netherlands Authority for the Financial Markets in Amsterdam.

This marketing document is solely intended for professional investors, defined as investors qualifying as professional clients, have requested to be treated as professional clients or are authorized to receive such information under any applicable laws. Robeco Institutional Asset Management B.V and/or its related, affiliated and subsidiary companies, (“Robeco”), will not be liable for any damages arising out of the use of this document. Users of this information who provide investment services in the European Union have their own responsibility to assess whether they are allowed to receive the information in accordance with MiFID II regulations. To the extent this information qualifies as a reasonable and appropriate minor non-monetary benefit under MiFID II, users that provide investment services in the European Union are responsible to comply with applicable recordkeeping and disclosure requirements.

The content of this document is based upon sources of information believed to be reliable and comes without warranties of any kind. Without further explanation this document cannot be considered complete. Any opinions, estimates or forecasts may be changed at any time without prior warning. If in doubt, please seek independent advice. It is intended to provide the professional investor with general information on Robeco’s specific capabilities, but has not been prepared by Robeco as investment research and does not constitute an investment recommendation or advice to buy or sell certain securities or investment products and/or to adopt any investment strategy and/or legal, accounting or tax advice. All rights relating to the information in this document are and will remain the property of Robeco. This material may not be copied or used with the public. No part of this document may be reproduced, or published in any form or by any means without Robeco's prior written permission.

Investment involves risks. Before investing, please note the initial capital is not guaranteed. Investors should ensure that they fully understand the risk associated with any Robeco product or service offered in their country of domicile. Investors should also consider their own investment objective and risk tolerance level. Historical returns are provided for illustrative purposes only. The price of units may go down as well as up and the past performance is not indicative of future performance. If the currency in which the past performance is displayed differs from the currency of the country in which you reside, then you should be aware that due to exchange rate fluctuations the performance shown may increase or decrease if converted into your local currency. The performance data do not take account of the commissions and costs incurred on trading securities in client portfolios or on the issue and redemption of units. Unless otherwise stated, the prices used for the performance figures of the Luxembourg-based Funds are the end-of-month transaction prices net of fees up to 4 August 2010. From 4 August 2010, the transaction prices net of fees will be those of the first business day of the month. Return figures versus the benchmark show the investment management result before management and/or performance fees; the Fund returns are with dividends reinvested and based on net asset values with prices and exchange rates of the valuation moment of the benchmark. Please refer to the prospectus of the Funds for further details. Performance is quoted net of investment management fees. The ongoing charges mentioned in this document are the ones stated in the Fund's latest annual report at closing date of the last calendar year.

This document is not directed to, or intended for distribution to or use by any person or entity who is a citizen or resident of or located in any locality, state, country or other jurisdiction where such distribution, document, availability or use would be contrary to law or regulation or which would subject any Fund or Robeco Institutional Asset Management B.V. to any registration or licensing requirement within such jurisdiction. Any decision to subscribe for interests in a Fund offered in a particular jurisdiction must be made solely on the basis of information contained in the prospectus, which information may be different from the information contained in this document. Prospective applicants for shares should inform themselves as to legal requirements also applying and any applicable exchange control regulations and applicable taxes in the countries of their respective citizenship, residence or domicile.

The Fund information, if any, contained in this document is qualified in its entirety by reference to the prospectus, and this document should, at all times, be read in conjunction with the prospectus. Detailed information on the Fund and associated risks is contained in the prospectus. The prospectus and the Key Investor Information Document for the Robeco Funds can all be obtained free of charge at Robeco website.

Additional Information for US investors
Robeco is considered “participating affiliated” and some of their employees are “associated persons” of Robeco Institutional Asset Management US Inc. (“RIAM US”) as per relevant SEC no-action guidance. Employees identified as associated persons of RIAM US perform activities directly or indirectly related to the investment advisory services provided by RIAM US. In those situation these individuals are deemed to be acting on behalf of RIAM US, a US SEC registered investment adviser. SEC regulations are applicable only to clients, prospects and investors of RIAM US. RIAM US is wholly owned subsidiary of ORIX Corporation Europe N.V. and offers investment advisory services to institutional clients in the US.

Additional Information for investors with residence or seat in Australia and New Zealand
This document is distributed in Australia by Robeco Hong Kong Limited (ARBN 156 512 659) (“Robeco”), which is exempt from the requirement to hold an Australian financial services license under the Corporations Act 2001 (Cth) pursuant to ASIC Class Order 03/1103. Robeco is regulated by the Securities and Futures Commission under the laws of Hong Kong and those laws may differ from Australian laws. This document is distributed only to “wholesale clients” as that term is defined under the Corporations Act 2001 (Cth). This document is not for distribution or dissemination, directly or indirectly, to any other class of persons. In New Zealand, this document is only available to wholesale investors within the meaning of clause 3(2) of Schedule 1 of the Financial Markets Conduct Act 2013 (‘FMCA’). This document is not for public distribution in Australia and New Zealand.

Important information

Additional Information for investors with residence or seat in Austria
This information is solely intended for professional investors or eligible counterparties in the meaning of the Austrian Securities Oversight Act.

Additional Information for investors with residence or seat in Brazil
The Fund may not be offered or sold to the public in Brazil. Accordingly, the Fund has not been nor will be registered with the Brazilian Securities Commission – CVM, nor has it been submitted to the foregoing agency for approval. Documents relating to the Fund, as well as the information contained therein, may not be supplied to the public in Brazil, as the offering of the Fund is not a public offering of securities in Brazil, nor may they be used in connection with any offer for subscription or sale of securities to the public in Brazil.

Additional Information for investors with residence or seat in Canada
No securities commission or similar authority in Canada has reviewed or in any way passed upon this document or the merits of the securities described herein, and any representation to the contrary is an offence. Robeco Institutional Asset Management B.V. is relying on the international dealer and international adviser exemption in Quebec and has appointed McCarthy Tétrault LLP as its agent for service in Quebec.

Additional information for investors with residence or seat in the Republic of Chile
Neither Robeco nor the Robeco funds have been registered with the Comisión para el Mercado Financiero pursuant to law no. 18.045, the Ley de Mercado de Valores and regulations thereunder. This document does not constitute an offer of, or an invitation to subscribe for or purchase, shares of the Funds in the Republic of Chile, other than to the specific person who individually requested this information on his own initiative. This may therefore be treated as a “private offering” within the meaning of article 4 of the Ley de Mercado de Valores (an offer that is not addressed to the public at large or to a certain sector or specific group of the public).

Additional Information for investors with residence or seat in Colombia
This document does not constitute a public offer in the Republic of Colombia. The offer of the Fund is addressed to less than one hundred specifically identified investors. The Fund may not be promoted or marketed in Colombia or to Colombian residents, unless such promotion and marketing is made in compliance with Decree 2555 of 2010 and other applicable rules and regulations related to the promotion of foreign Funds in Colombia.

Additional Information for investors with residence or seat in the Dubai International Financial Centre (DIFC), United Arab Emirates
This material is being distributed by Robeco Institutional Asset Management B.V. (DIFC Branch) located at Office 209, Level 2, Gate Village Building 7, Dubai International Financial Centre, Dubai, PO Box 482060, UAE. Robeco Institutional Asset Management B.V. (DIFC Branch) is regulated by the Dubai Financial Services Authority (“DFSA”) and only deals with Professional Clients or Market Counterparties and does not deal with Retail Clients as defined by the DFSA.

Additional Information for investors with residence or seat in France
Robeco Institutional Asset Management B.V. is at liberty to provide services in France. Robeco France is a subsidiary of Robeco whose business is based on the promotion and distribution of the group's funds to professional investors in France.

Additional Information for investors with residence or seat in Germany
This information is solely intended for professional investors or eligible counterparties in the meaning of the German Securities Trading Act.

Additional Information for investors with residence or seat in Hong Kong
The contents of this document have not been reviewed by the Securities and Futures Commission (“SFC”) in Hong Kong. If you are in any doubt about any of the contents of this document, you should obtain independent professional advice. This document has been distributed by Robeco Hong Kong Limited (“Robeco”). Robeco is regulated by the SFC in Hong Kong.

Additional Information for investors with residence or seat in Italy
This document is considered for use solely by qualified investors and private professional clients (as defined in Article 26 (1) (b) and (d) of Consob Regulation No. 16190 dated 29 October 2007). If made available to Distributors and individuals authorized by Distributors to conduct promotion and marketing activity, it may only be used for the purpose for which it was conceived. The data and information contained in this document may not be used for communications with Supervisory Authorities. This document does not include any information to determine, in concrete terms, the investment inclination and, therefore, this document cannot and should not be the basis for making any investment decisions.

Additional Information for investors with residence or seat in Japan
This documents are considered for use solely by qualified investors and are being distributed by Robeco Japan Company Limited, registered in Japan as a Financial Instruments Business Operator, [registered No. the Director of Kanto Local Financial Bureau (Financial Instruments Business Operator), No, 2780, Member of Japan Investment Advisors Association].

Additional Information for investors with residence or seat in Mexico
The funds have not been and will not be registered with the National Registry of Securities, maintained by the Mexican National Banking and Securities Commission and, as a result, may not be offered or sold publicly in Mexico. Robeco and any underwriter or purchaser may offer and sell the funds in Mexico on a private placement basis to Institutional and Accredited Investors, pursuant to Article 8 of the Mexican Securities Market Law.

Additional Information for investors with residence or seat in Peru
The Fund has not been registered with the Superintendencia del Mercado de Valores (SMV) and is being placed by means of a private offer. SMV has not reviewed the information provided to the investor. This document is only for the exclusive use of institutional investors in Peru and is not for public distribution.

Important information

Additional Information for investors with residence or seat in Shanghai
This material is prepared by Robeco Overseas Investment Fund Management (Shanghai) Limited Company ("Robeco Shanghai") and is only provided to the specific objects under the premise of confidentiality. Robeco Shanghai was registered as a private fund manager with the Asset Management Association of China in September 2018. Robeco Shanghai is a wholly foreign-owned enterprise established in accordance with the PRC laws, which enjoys independent civil rights and civil obligations. The statements of the shareholders or affiliates in the material shall not be deemed to a promise or guarantee of the shareholders or affiliates of Robeco Shanghai, or be deemed to any obligations or liabilities imposed to the shareholders or affiliates of Robeco Shanghai.

Additional Information for investors with residence or seat in Singapore
This document has not been registered with the Monetary Authority of Singapore ("MAS"). Accordingly, this document may not be circulated or distributed directly or indirectly to persons in Singapore other than (i) to an institutional investor under Section 304 of the SFA, (ii) to a relevant person pursuant to Section 305(1), or any person pursuant to Section 305(2), and in accordance with the conditions specified in Section 305, of the SFA, or (iii) otherwise pursuant to, and in accordance with the conditions of, any other applicable provision of the SFA. The contents of this document have not been reviewed by the MAS. Any decision to participate in the Fund should be made only after reviewing the sections regarding investment considerations, conflicts of interest, risk factors and the relevant Singapore selling restrictions (as described in the section entitled "Important Information for Singapore Investors") contained in the prospectus. You should consult your professional adviser if you are in doubt about the stringent restrictions applicable to the use of this document, regulatory status of the Fund, applicable regulatory protection, associated risks and suitability of the Fund to your objectives. Investors should note that only the sub-Funds listed in the appendix to the section entitled "Important Information for Singapore Investors" of the prospectus ("Sub-Funds") are available to Singapore investors. The Sub-Funds are notified as restricted foreign schemes under the Securities and Futures Act, Chapter 289 of Singapore ("SFA") and are invoking the exemptions from compliance with prospectus registration requirements pursuant to the exemptions under Section 304 and Section 305 of the SFA. The Sub-Funds are not authorized or recognized by the MAS and shares in the Sub-Funds are not allowed to be offered to the retail public in Singapore. The prospectus of the Fund is not a prospectus as defined in the SFA. Accordingly, statutory liability under the SFA in relation to the content of prospectuses would not apply. The Sub-Funds may only be promoted exclusively to persons who are sufficiently experienced and sophisticated to understand the risks involved in investing in such schemes, and who satisfy certain other criteria provided under Section 304, Section 305 or any other applicable provision of the SFA and the subsidiary legislation enacted thereunder. You should consider carefully whether the investment is suitable for you. Robeco Singapore Private Limited holds a capital markets services license for fund management issued by the MAS and is subject to certain clientele restrictions under such license.

Additional Information for investors with residence or seat in Malaysia
Generally, no offer or sale of the Shares is permitted in Malaysia unless where a Recognition Exemption or the Prospectus Exemption applies: NO ACTION HAS BEEN, OR WILL BE, TAKEN TO COMPLY WITH MALAYSIAN LAWS FOR MAKING AVAILABLE, OFFERING FOR SUBSCRIPTION OR PURCHASE, OR ISSUING ANY INVITATION TO SUBSCRIBE FOR OR PURCHASE OR SALE OF THE SHARES IN MALAYSIA OR TO PERSONS IN MALAYSIA AS THE SHARES ARE NOT INTENDED BY THE ISSUER TO BE MADE AVAILABLE, OR MADE THE SUBJECT OF ANY OFFER OR INVITATION TO SUBSCRIBE OR PURCHASE, IN MALAYSIA. NEITHER THIS DOCUMENT NOR ANY DOCUMENT OR OTHER MATERIAL IN CONNECTION WITH THE SHARES SHOULD BE DISTRIBUTED, CAUSED TO BE DISTRIBUTED OR CIRCULATED IN MALAYSIA. NO PERSON SHOULD MAKE AVAILABLE OR MAKE ANY INVITATION OR OFFER OR INVITATION TO SELL OR PURCHASE THE SHARES IN MALAYSIA UNLESS SUCH PERSON TAKES THE NECESSARY ACTION TO COMPLY WITH MALAYSIAN LAWS.

Additional Information for investors with residence or seat in Thailand
The Prospectus has not been approved by the Securities and Exchange Commission which takes no responsibility for its contents. No offer to the public to purchase the Shares will be made in Thailand and the Prospectus is intended to be read by the addressee only and must not be passed to, issued to, or shown to the public generally.

Additional Information for investors with residence or seat in Brunei
The Prospectus relates to a private collective investment scheme which is not subject to any form of domestic regulations by the Autoriti Monetari Brunei Darussalam ("Authority"). The Prospectus is intended for distribution only to specific classes of investors as specified in section 20 of the Securities Market Order, 2013, and must not, therefore, be delivered to, or relied on by, a retail client. The Authority is not responsible for reviewing or verifying any prospectus or other documents in connection with this collective investment scheme. The Authority has not approved the Prospectus or any other associated documents nor taken any steps to verify the information set out in the Prospectus and has no responsibility for it. The units to which the Prospectus relates may be illiquid or subject to restrictions on their resale. Prospective purchasers of the units offered should conduct their own due diligence on the units.

Additional Information for investors with residence or seat in Indonesia
The Prospectus does not constitute an offer to sell nor a solicitation to buy securities in Indonesia.

Additional Information for investors with residence or seat in Spain
Robeco Institutional Asset Management BV, Sucursal en España with identification number W0032687F and having its registered office in Madrid at Calle Serrano 47-14º, is registered with the Spanish Commercial Registry in Madrid, in volume 19.957, page 190, section 8, sheet M-351927 and with the National Securities Market Commission (CNMV) in the Official Register of branches of European investment services companies, under number 24. The investment funds or SICAV mentioned in this document are regulated by the corresponding authorities of their country of origin and are registered in the Special Registry of the CNMV of Foreign Collective Investment Institutions marketed in Spain.