

October 2017

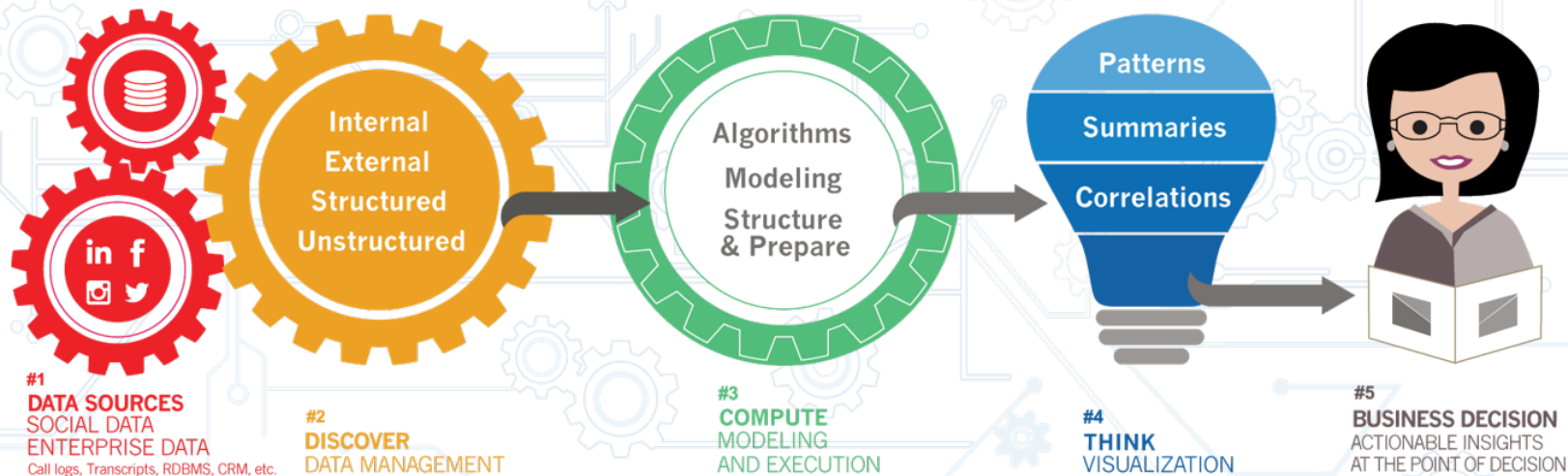
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Head of Systematic Strategies

A MACHINE LEARNING REVOLUTION



GUARDIAN CAPITAL

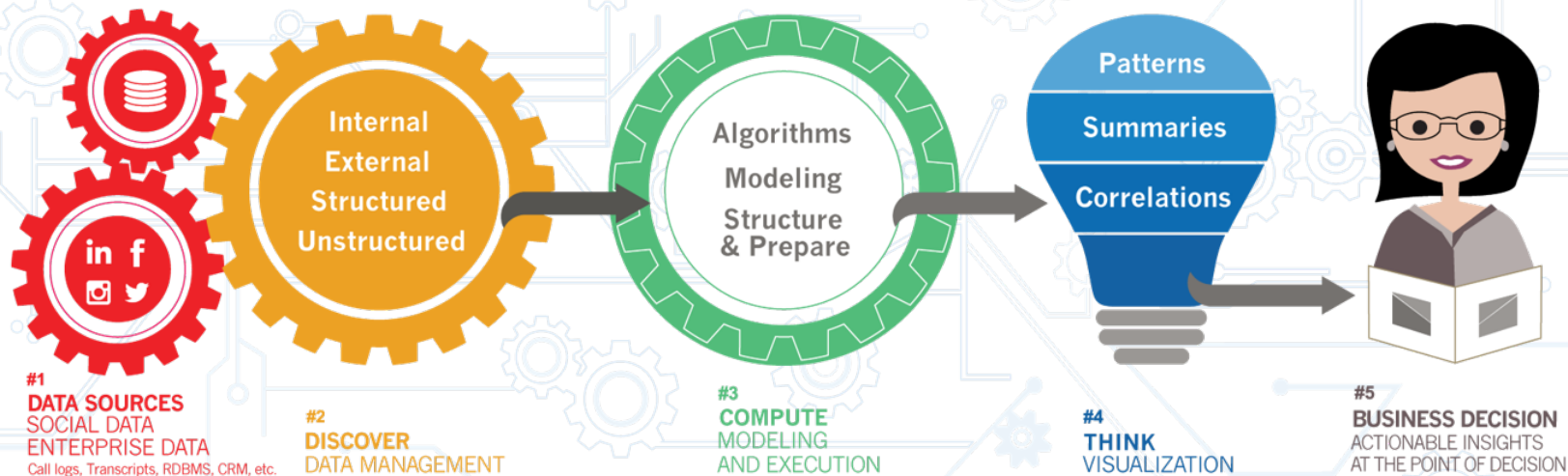
TRENDS THAT HAVE ENABLED THE BIG DATA REVOLUTION



Exponential increase in amount of data available

- **90% of the data in the world** has been created in the past two years alone. (IBM: "Bringing Big Data to Enterprise".)
- Data flood expected to **increase** the digital universe of data from 4.4 zettabytes (or trillion Giga Bytes) in 2015 to **44 zettabytes by 2020**. (EMC: "The Digital Universe of Opportunities".)
- Internet of Things (IoT) driven by embedded networked sensors into home appliances, collection of data through sensors in smart phones, and reduction of costs in satellite technology. (J.P Morgan: Big Data and AI)

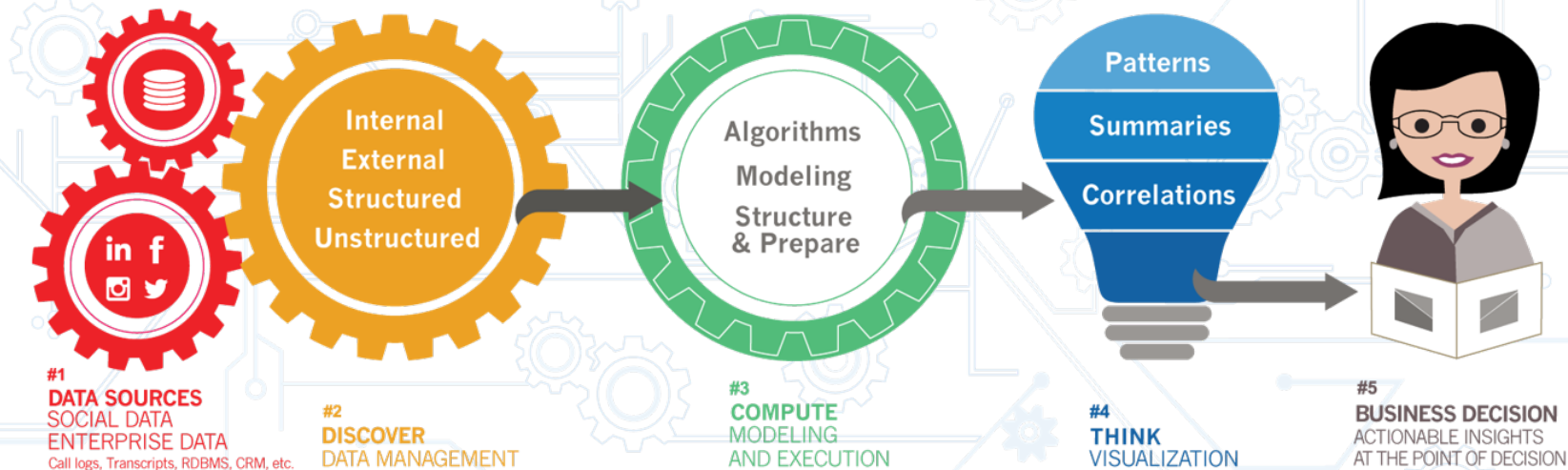
TRENDS THAT HAVE ENABLED THE BIG DATA REVOLUTION



Increase in computing power and storage capacity

- Parallel distributed/computing and increased storage capacity made available remotely from shared access of resources at a reduced cost. (Also known as Cloud Computing)
- A single web search on Google is said to be answered through coordination across a **1000 computers**, (*Internet Live States*, "Google Search Statistics".)
- By 2020 1/3 of all data will **live in or pass through the cloud**.
- Open source frameworks for splitting complex task across multiple machines and aggregating results has dramatically diminished barriers to entry allowing for large scale data processing and opening up big/alternative data based strategies to a wide group of quantitative investors.

TRENDS THAT HAVE ENABLED THE BIG DATA REVOLUTION



Significant developments in Machine Learning (Artificial Intelligence et al) methods

- **Revolution in integration** of Statistics and Computer Science
- **Big strides in pattern recognition** and uncovering relationships between variables
- Increased focus on investment applications of **Deep Learning** (multi layered Neural Networks) to enable machines to think like humans
- 2016 saw **widespread adoption** of Amazon Echo, Google Home and Apple Siri, which rely heavily on Deep Learning Algorithms.



What is Big Data?

The systematic collection of large amounts of novel data supported by their organization and dissemination.

Why the word Big?

1. Volume: Massive size of data collected
2. Velocity: The speed with which data is sent or received
3. Variety: Multiple formats – structured (SQL tables, CSV files), unstructured (HTML, media, text, blogs and videos)

Classification of Big/Alternative Data



Individuals

Social Media

News and Reviews

Web Searches, Personal Data

Business Processes

Credit Card Transactions

Corporate Data

Government Agencies Data

Technology

Satellites

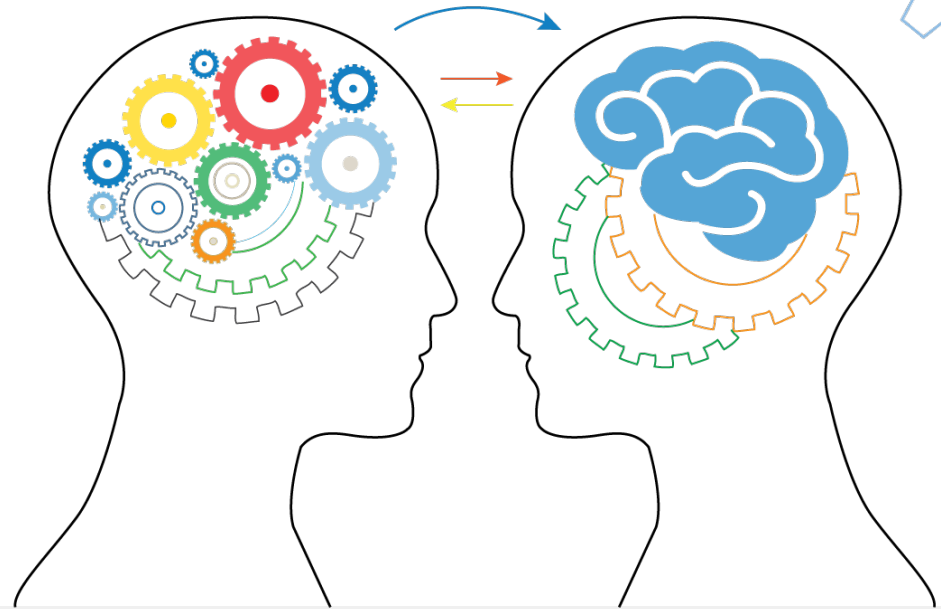
Geolocation

Sensors, IoT

What is Artificial Intelligence (AI)



- Artificial Intelligence is a schema for enabling machines to have human-like cognitive intelligence and is similar to how people learn and a genuine attempt to artificially recreate human intelligence.
- The goal of Machine Learning is to enable computers to learn from their experience in certain tasks. A self driving car learns from initially being driven by human driver; as it drives itself, it reinforces its own learning and gets better with experience.
- Machine learning methods attempt to uncover relationships between variables: where given historical patterns (both input and output), the machine forecasts outcomes out of sample.



Supervised Learning: Regressions, classifications

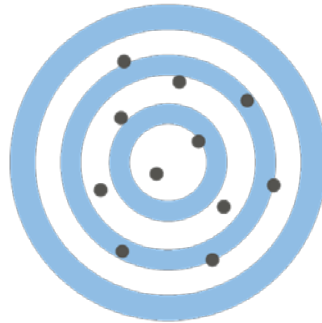
Unsupervised Learning: PCA, Regime detection

Deep Learning: Process unstructured data like images, voice, sentiment

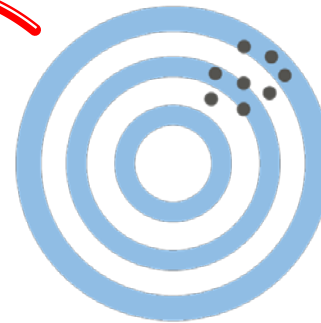
Prediction using Machine Learning

Complex Model

Low Bias, High Variance
Higher Accuracy in
predicting but Noisy



SINGLE
DIVIDEND
GROWTH
ESTIMATE

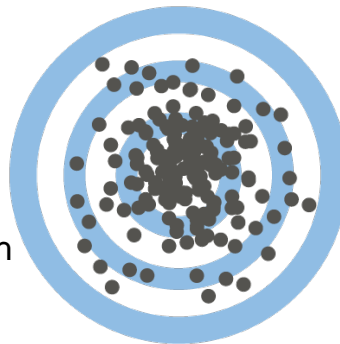


Simple Model

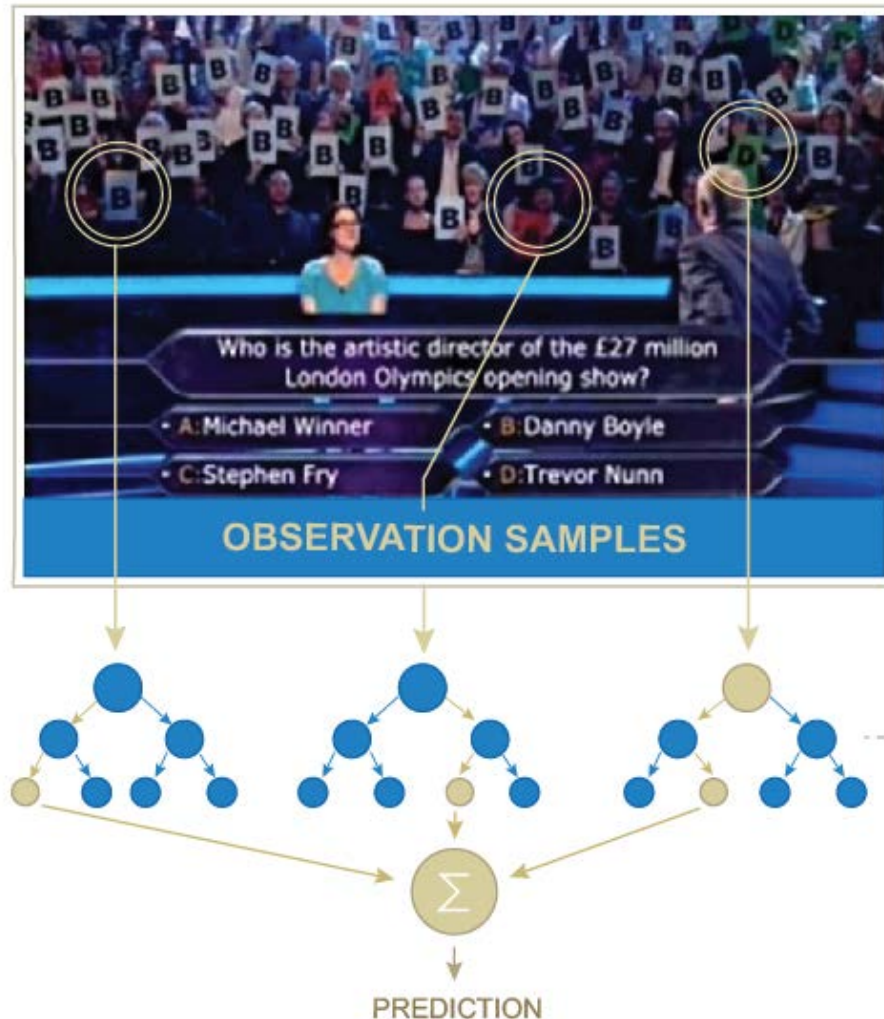
High Bias, Low
Variance Higher
Precision but
bad predictor

Machine Learning – Supervised Ensemble Model

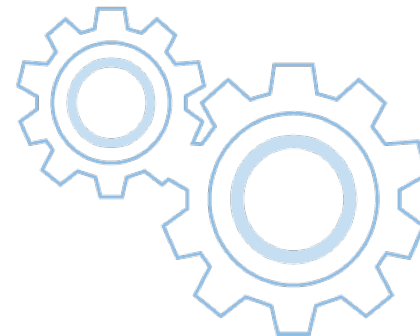
Optimal Bias and Variance
By overlaying thousands of the low-bias, high
variance dividend growth estimates we can
see that they cluster around the bulls-eye,
which is reflected in an accurate and precise
average dividend growth rate.



Our Approach to **Machine Learning**



The collective intelligence of a diverse and independent group typically yields better estimates than any one superior individual



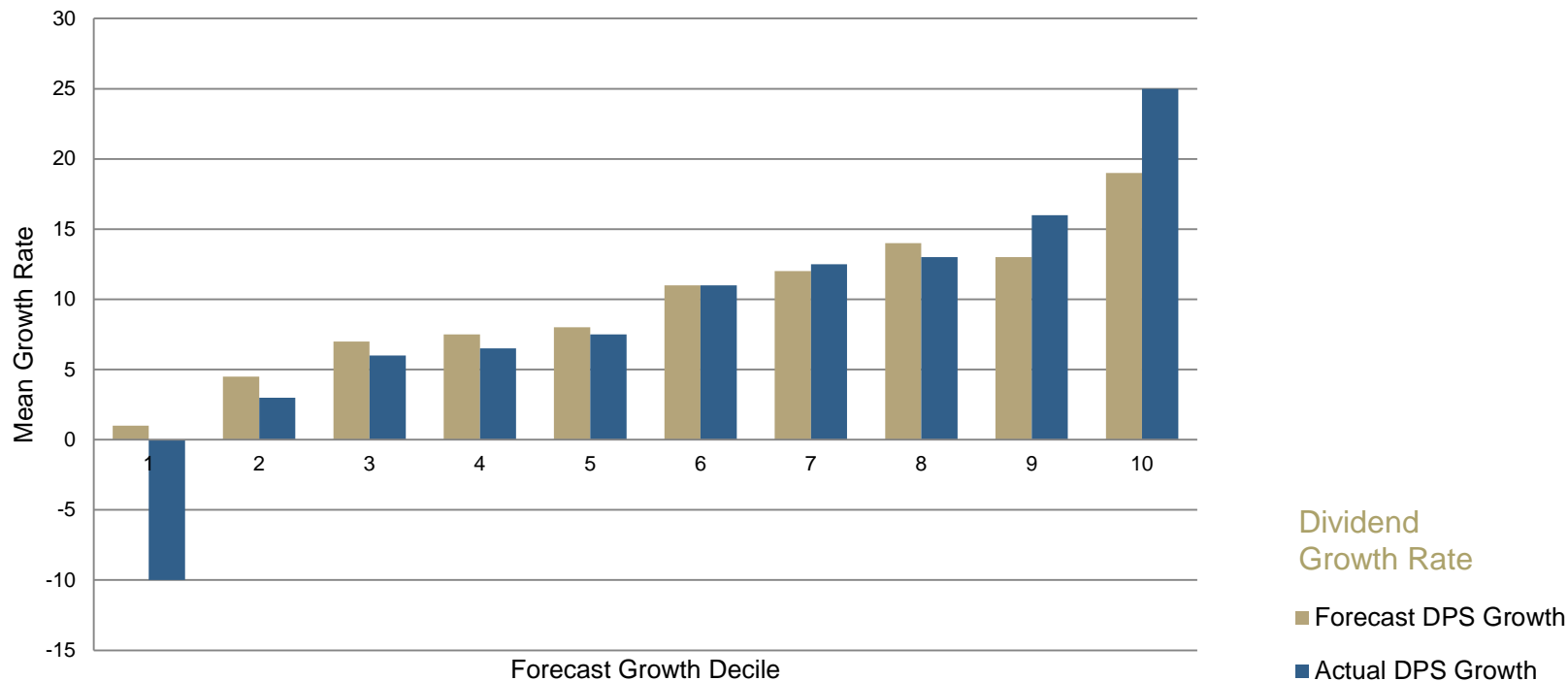
Feature Engineering: making AI work for you

Category	Factor	Economic and Machine Inference
Dividend	Trailing Yield	High dividend more difficult to sustain
	IBES Forecast Yield	High dividend more difficult to sustain
	Earnings Coverage	Coverage measures sustainability
	Dividend Trailing Growth	Growing dividends means less likely to cut
	IBES Forecast Div Growth	Growing dividends means less likely to cut
Market	Momentum	Strong momentum means company is doing well
	Volatility	Bad news and volatility are correlated
	Change in Volatility	Bad news and change in volatility are correlated
Earnings	Earnings Growth LTM	Earnings Growth affects ability to pay
	Earnings Growth Forecast	Earnings Growth affects ability to pay
	Earnings Revision	Earnings revision reflect market sentiment
	EPS Coefficient of Variation	Captures uncertainty of future earnings
Quality	Book to Price	High Book to Price indicates possible distress
	Debt to EV	Debt reduces cash for dividends
	Cash to Total Assets	Low cash is a sign of distress
	ROIC	Unprofitable companies are forced to cut dividends
	ROE	Unprofitable companies are forced to cut dividends

Forecasting Dividend Growth



Forecast vs. Actual Average Dividend Growth Rate



Source: Guardian Capital LP

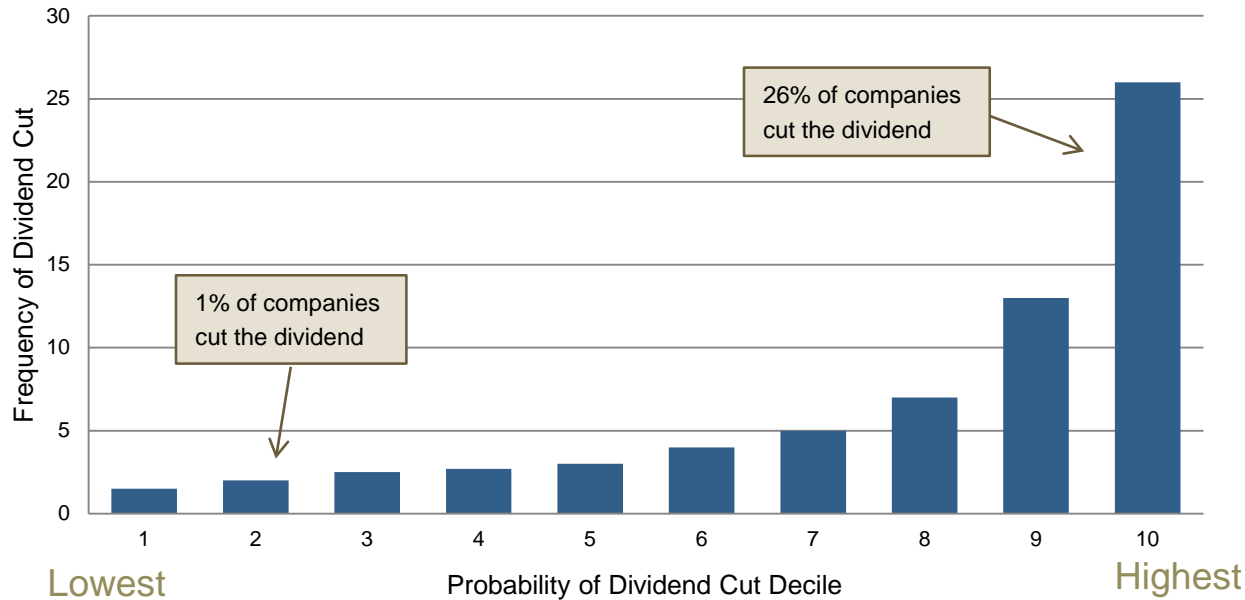
- Validates the model – the trend in forecasting dividend growth matches forward reality of DPS growth



Forecasting Probability of Dividend Cut



Proportion of Dividend Reduction by Probability of Cut Decile



The proportion of companies that actually cut the dividend over the following 12m.

Source: Guardian Capital LP

- Accurate forecasting is evident through outsized dividend cuts in higher deciles.



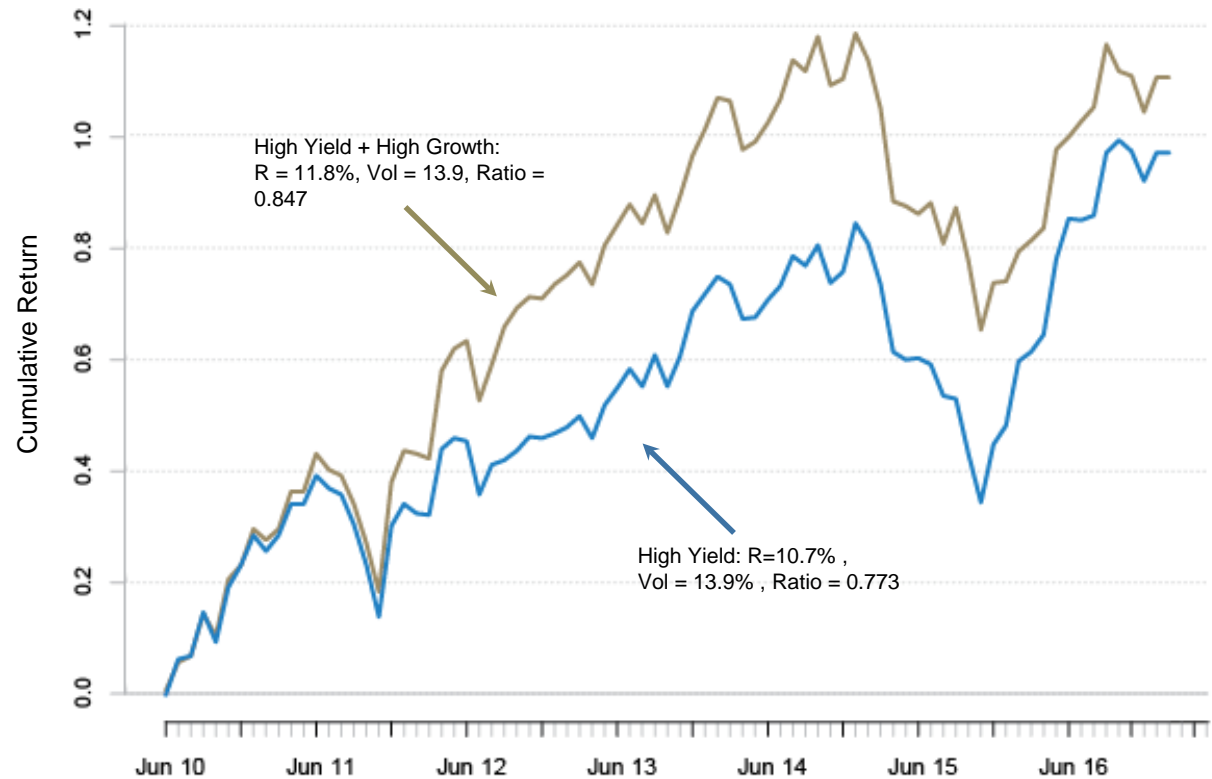


Machine Learning: Highest Yield + Highest Growth

Highest Dividend Yield + Highest Dividend Growth Rate outperforms Highest Yield on annualized return and risk-adjusted returns, higher Sharpe, and has a hit rate of **58.7%**.

Validates our hypothesis in addition to helping identify quality companies that are more likely to grow their dividend.

High Yield Vs. High Yield + Growth



Source: Guardian Capital LP

Yield for Yield Sake is Dangerous



Expected Dividend Growth & Probability of Cut: Portfolio vs. Top Quintile Dividend Payers from MSCI World Index

*12-Months Ending
June 30th, 2017

Sector	Yield		Expected Dividend Growth		Probability of Dividend Cut	
	Portfolio	Top Quintile	Portfolio	Top Quintile	Portfolio	Top Quintile
Consumer Discretion	3.07	4.79	7.29	1.75	5.09	21.07
Consumer Staples	3.31	3.45	7.47	4.93	7.23	7.14
Energy	6.13	6.29	8.01	3.3	8.85	14.48
Financials	3.31	5.68	8.78	6.43	5.13	15.44
Health Care	2.79	3.38	5.68	3.82	4.54	7.22
Industrials	2.93	3.48	7.72	5.68	7.09	8.72
Information Tech	2.16	3.47	12.11	5.83	2.52	5.03
Materials	3.18	3.58	7.50	12.15	3.48	8.13
Real Estate	4.84	5.18	2.40	5.13	22.62	10.92
Telecommunications	5.00	7.78	5.15	1.68	8.73	16.79
Utilities	4.56	5.55	5.93	3.15	5.92	16.53
TOTAL	3.46	5.03	7.80	5.76	6.23	12.52

Source: Guardian Capital LP

Safest Dividends

- List of position in the portfolio that represent the top quintile (lowest chance of a dividend cut based upon our Machine Learning (AI) based models.

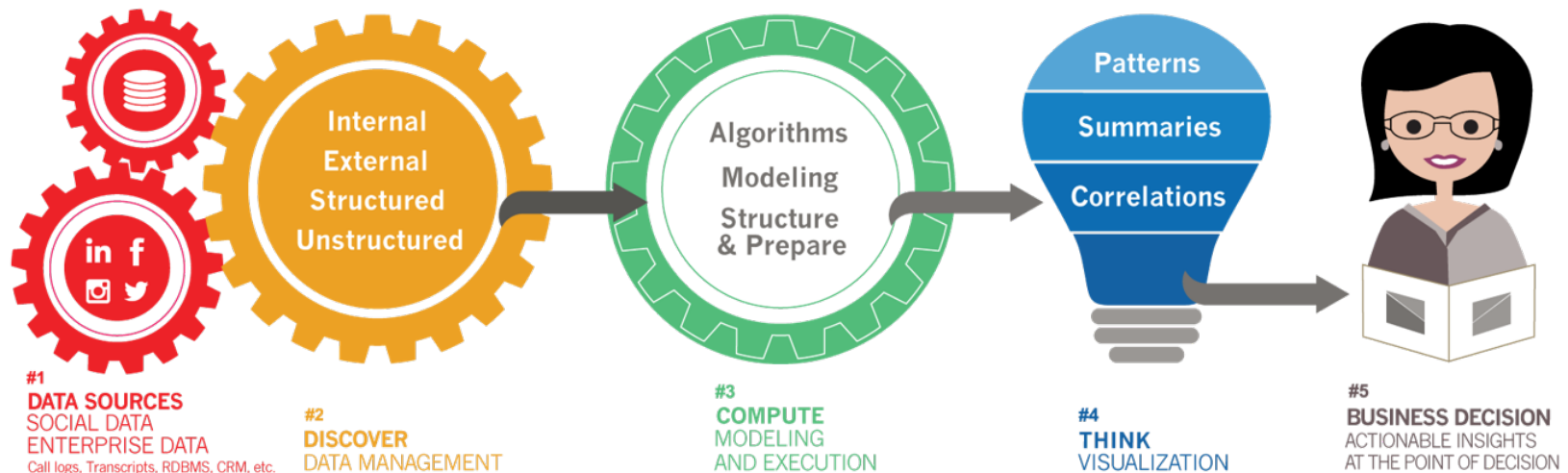
	Region	Sector	Industry	Dividend Yield%	Forecast Probability of Dividend Cut 1yr
HANESBRANDS, INC.	US	CONSUMER DISCRETION	Textiles, Apparel & Luxury Goods	2.34	2.75
MCDONALD'S CORPORATION	US	CONSUMER DISCRETION	Hotels, Restaurants & Leisure	2.41	3.65
HOME DEPOT INC	US	CONSUMER DISCRETION	Specialty Retail	2.23	4.05
DR PEPPER SNAPPLE GROUP	US	CONSUMER STAPLES	Beverages	2.52	2.00
KIMBERLY-CLARK CORPORATION	US	CONSUMER STAPLES	Household Products	3.22	2.50
UNILEVER N.V.	Europe	CONSUMER STAPLES	Food Products	2.69	4.05
BRITISH AMERICAN TOBACCO P.L.C.	Europe	CONSUMER STAPLES	Tobacco	3.55	6.15
NESTLE S.A.	Europe	CONSUMER STAPLES	Food Products	2.85	6.35
ENTERPRISE PRODUCTS PARTNERS LP	US	ENERGY	Oil, Gas & Consumable Fuels	6.44	1.70
ENERGY TRANSFER EQUITY LP	US	ENERGY	Oil, Gas & Consumable Fuels	6.42	5.40
ROYAL BANK OF CANADA	Canada	FINANCIALS	Banks	3.96	0.85
CHUBB LTD	US	FINANCIALS	Insurance	1.93	0.90
WELLS FARGO & COMPANY	US	FINANCIALS	Banks	3.03	2.30
ING GROEP N.V.	Europe	FINANCIALS	Banks	4.49	3.85
SCOR SE	Europe	FINANCIALS	Insurance	4.98	10.70
PFIZER INC.	US	HEALTH CARE	Pharmaceuticals	3.62	1.40
STRYKER CORPORATION	US	HEALTH CARE	Health Care Equipment & Supplies	1.18	1.55
AMGEN INC.	US	HEALTH CARE	Biotechnology	2.41	1.65
JOHNSON & JOHNSON	US	HEALTH CARE	Pharmaceuticals	2.53	1.65
MERCK & CO. , INC.	US	HEALTH CARE	Pharmaceuticals	2.87	2.15
NOVO NORDISK AS	Europe	HEALTH CARE	Pharmaceuticals	2.56	4.40
ACCENTURE PLC	US	INFORMATION TECH	IT Services	1.78	0.55
XILINX, INC.	US	INFORMATION TECH	Semiconductors & Semiconductor Equipment	2.15	1.15
TEXAS INSTRUMENTS INCORPORATED	US	INFORMATION TECH	Semiconductors & Semiconductor Equipment	2.41	2.05
APPLE INC.	US	INFORMATION TECH	Technology Hardware, Storage & Peripherals	1.57	2.20
PAYCHEX, INC.	US	INFORMATION TECH	IT Services	3.44	2.45
AMADEUS IT GROUP SA	Europe	INFORMATION TECH	IT Services	1.78	3.70
BASF SE	Europe	MATERIALS	Chemicals	3.55	7.15
BCE INC	Canada	TELECOMMUNICATION	Diversified Telecommunication Services	4.91	0.55
TELUS CORPORATION	Canada	TELECOMMUNICATION	Diversified Telecommunication Services	4.48	0.55
VERIZON COMMUNICATIONS	US	TELECOMMUNICATION	Diversified Telecommunication Services	5.04	1.80
AT&T INC.	US	TELECOMMUNICATION	Diversified Telecommunication Services	5.41	5.95
SPARK NEW ZEALAND LTD	Asia Pacific	TELECOMMUNICATION	Diversified Telecommunication Services	5.63	12.30
DUKE ENERGY CORP	US	UTILITIES	Electric Utilities	4.08	1.55
PPL CORP	US	UTILITIES	Electric Utilities	4.04	1.55
SNAM SPA	Europe	UTILITIES	Gas Utilities	5.04	6.75
E.ON SE	Europe	UTILITIES	Multi-Utilities	3.13	7.05

Fastest Growing Dividends in the Portfolio

- List of the top Quintile (top 20%) of portfolio holdings with the highest prediction of future divided growth based upon our Machine Learning (AI) based models.

	Region	Sector	Industry	Dividend Yield%	Dividend 3yr Growth	Forecast Dividend Growth 1yr
HOME DEPOT INC	US	CONSUMER DISCRETION	Specialty Retail	2.23	20.95	11.52
HANESBRANDS, INC.	US	CONSUMER DISCRETION	Textiles, Apparel & Luxury Goods	2.34	43.15	11.03
PULTEGROUP, INCORPORATION	US	CONSUMER DISCRETION	Household Durables	1.36	53.26	10.33
SWEDISH MATCH AB	Europe	CONSUMER STAPLES	Tobacco	5.62	29.90	17.47
UNILEVER N.V.	Europe	CONSUMER STAPLES	Food Products	2.69	5.47	12.95
ALTRIA GROUP, INC.	US	CONSUMER STAPLES	Tobacco	4.22	8.50	7.27
BANK OF AMERICA CORPORATION	US	FINANCIALS	Banks	2.00	84.20	16.05
JPMORGAN CHASE & CO.	US	FINANCIALS	Banks	2.20	9.29	11.25
STRYKER CORPORATION	US	HEALTH CARE	Health Care Equipment & Supplies	1.18	12.47	11.45
AMGEN INC.	US	HEALTH CARE	Biotechnology	2.41	28.62	9.38
SOJITZ CORPORATION	Asia Pacific	INDUSTRIALS	Trading Companies & Distributors	2.78	25.99	21.66
ILLINOIS TOOL WORKS INCORPORATED	US	INDUSTRIALS	Machinery	2.18	14.47	10.06
TOKYO ELECTRON LTD	Asia Pacific	INFORMATION TECH	Semiconductors & Semiconductor Equipment	2.31	91.66	22.06
BROADCOM LTD	US	INFORMATION TECH	Semiconductors & Semiconductor Equipment	1.65	53.41	19.61
ACCENTURE PLC	US	INFORMATION TECH	IT Services	1.78	9.91	13.53
TEXAS INSTRUMENTS INCORPORATED	US	INFORMATION TECH	Semiconductors & Semiconductor Equipment	2.41	15.30	12.47
ROGERS COMMUNICATIONS INC	Canada	TELECOMMUNICATION	Wireless Telecommunication Services	2.96	3.34	6.25
E.ON SE	Europe	UTILITIES	Multi-Utilities	3.13	-15.66	28.16
RWE AG	Europe	UTILITIES	Multi-Utilities	2.34	-20.63	17.03

A Machine Learning Revolution



Which one of these quotes will be the closest to our future reality

“The development of full artificial intelligence could spell the end of the human race....It would take off on its own, and re-design itself at an ever increasing rate. Humans, who are limited by slow biological evolution, couldn't compete, and would be superseded.” — *Stephen Hawking*

“The pace of progress in artificial intelligence is incredibly fast. You have no idea how fast—it is growing at a pace close to exponential. The risk of something seriously dangerous happening is in the five-year timeframe. 10 years at most.” — *Elon Musk wrote in a comment on Edge.org*

“Anything that could give rise to smarter-than-human intelligence—in the form of Artificial Intelligence, brain-computer interfaces, or neuroscience-based human intelligence enhancement - wins hands down beyond contest as doing the most to change the world. Nothing else is even in the same league.”

—*Eliezer Yudkowsky : AI Researcher*

“Some people worry that artificial intelligence will make us feel inferior, but then, anybody in his right mind should have an inferiority complex every time he looks at a flower.” —*Alan Kay : Computer Scientist*

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