Factor Models

FNCE 205 & 720 - Investment Management
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October 23, 2017

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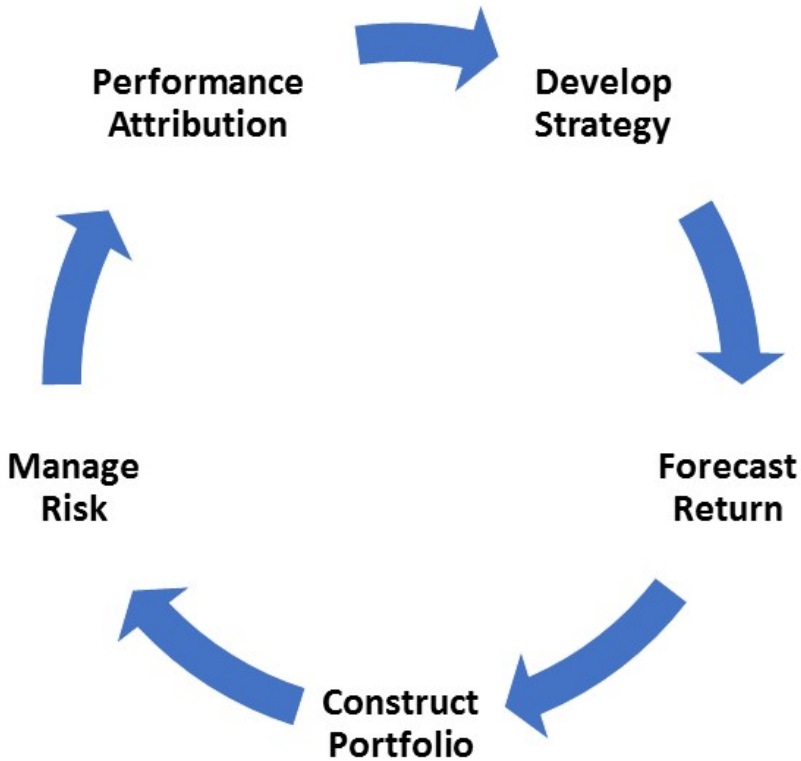


Why Factor Models?

- Simple description of the world
- Based on theory and experience
  - Supported by rigor using statistics
  - Data and empirics create insights
  - Link theory to real behavior or vice versus
- Provides a framework to make better decisions or drive decisions

Definition of Factor Models

$$\text{Return} = \beta * \text{Factor} + \text{Idiosyncratic Return}$$

- Model shows security expected returns linearly related to a factor(s)
- Factor models show that return is **proportional** to the security's exposure to the alpha that the factor represents
- Factors are chosen by the modeler
- Identifies idiosyncratic return
  - Return that is not explained by factors
  - Uncorrelated with factors
  - Mean of idiosyncratic return is 0

Building a Factor Model

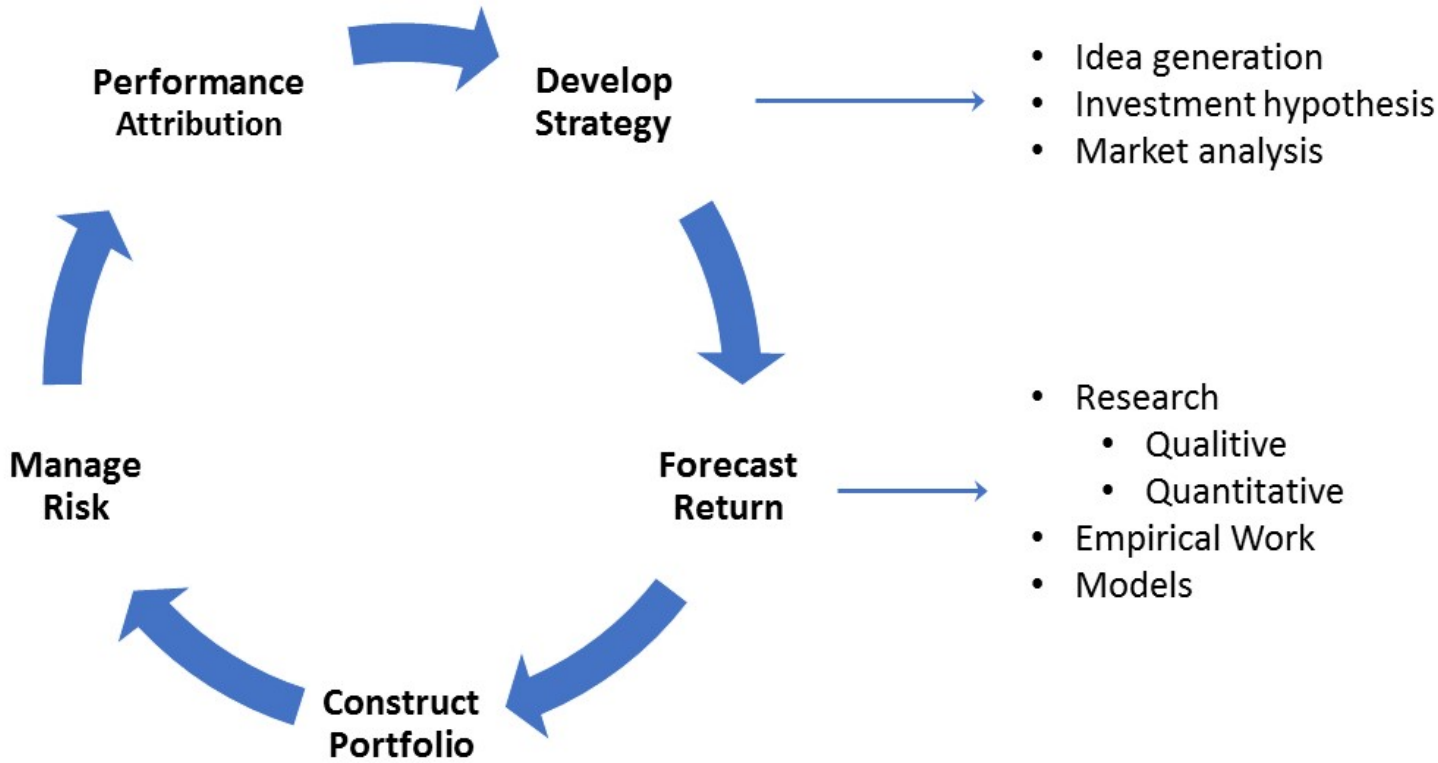
- Motivation
- Specification
- Data
- Computational Approach
- Evaluate the model
- Put into practice

Types of Factors

Factors represent

- Cross sectional characteristics
  - Firm specific attributes
  - Security related attributes
- Economic influences
  - Observable macroeconomic factors
- Statistical factors
  - Unobservable or latent factors

Investment Process



Forecasting Returns

Develop Strategy

- What drives the returns of securities?
- Do I have an edge on understanding these drivers?
- What risks will I be taking on?
- What is my confidence level in bearing this risk?
- Is there persistent compensation for bearing this drivers?

What forecasts asset prices?

List of factors

- Fundamentals
- Investor sentiment
- Price movements
- Risk aversion
- Macro environment
- Flows

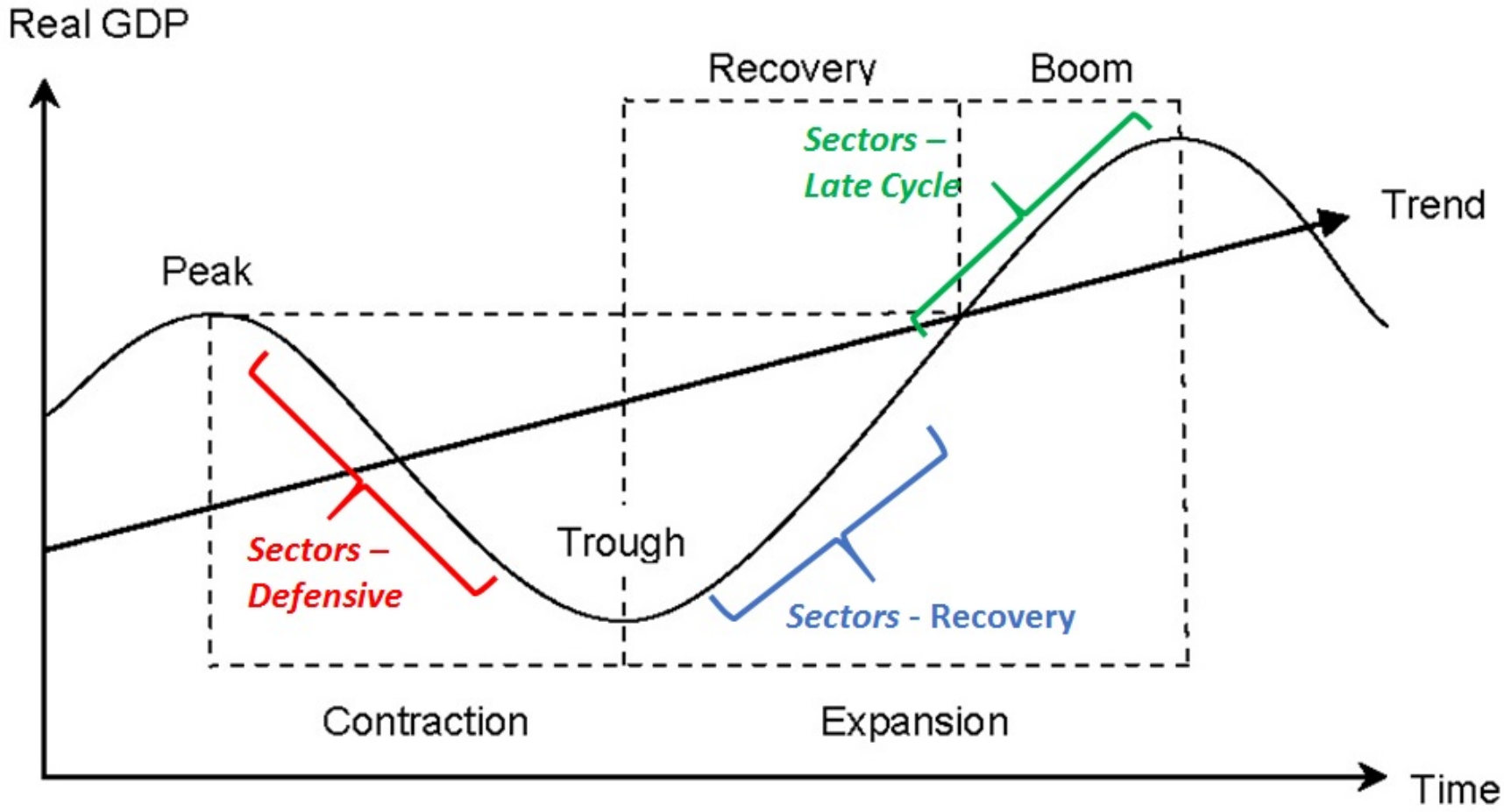
Building factors using data

What are the characteristics of good data?

- Clear and consistent definitions of what the data represent
- Reasonable detail underlying the data
- Appropriate data availability: length, frequency, timeliness
- Consistent view of history
- No survivorship bias
- No look ahead bias

Example: Sector returns and the business cycle

Investment Thesis



Source: NBER

Example: Factors for forecasting sector returns

To measure the economy we look at various statistics (indicators) about an economic activity. Economic indicators allow analysis of economic performance and predictions of future performance. Economic factors represent systematic exposures to securities.

- Leading
  - Manufacturing activity
  - Inventory levels
  - Retail sales
- Coincident
  - Personal income
  - GDP
- Lagging series
  - Unemployment
  - Inflation

Statistical Factors

Statistical techniques designed to jointly estimate the factors and their sensitivities. Dimension reduction techniques that extract the most important factors from data.

- Factor Analysis
- Principal Components

Example: Stock Selection

Building factors from company characteristics

- Explicit link between factors and economic intuition
- Relate financial data to metrics that investors will use to make decisions
  - Valuation
  - Operating efficiency
  - Profitability
  - Solvency
  - Analyst forecast
  - Momentum

Example: Building a quality signal

Fundamentals that rank the quality of a company based on how well management executes, the financial strength, and the ability to innovative . These attributes create abnormal profits and shareholder value.

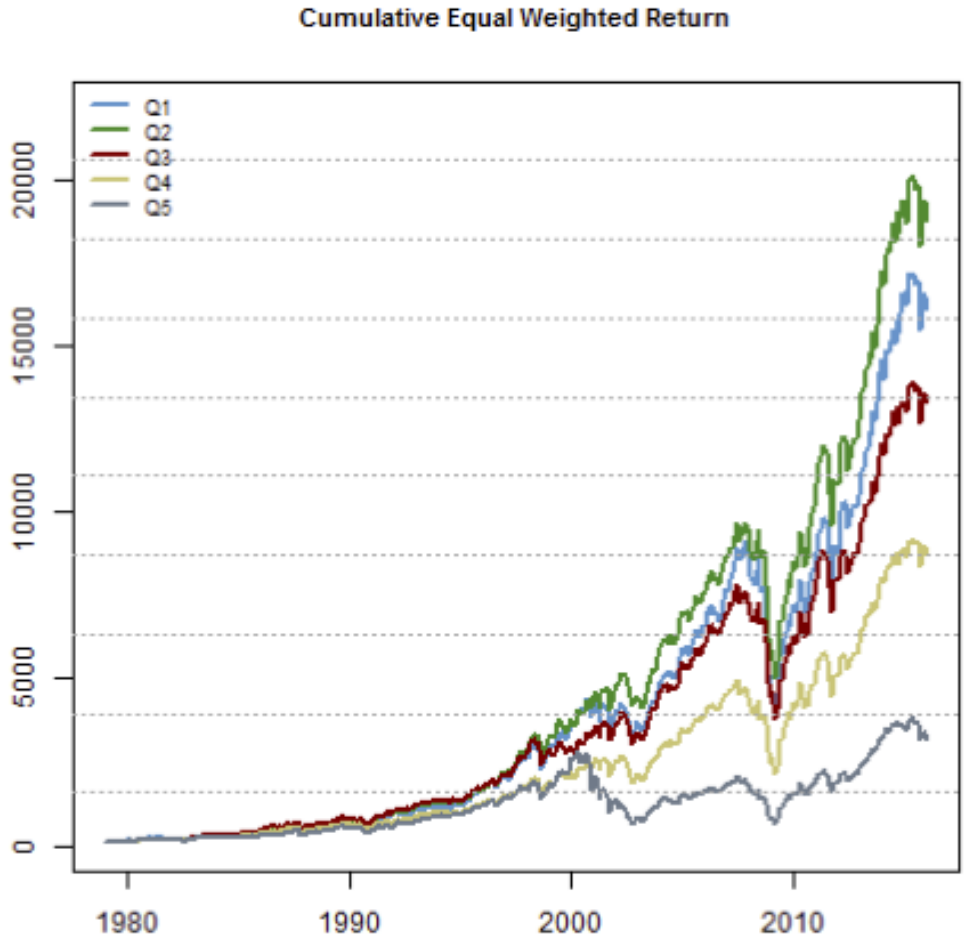
- Return on equity (roe): Measures the profitability of a company
- Volatility of ROE (vroe): Measures the variability of the profitability of the company
- Earnings before interest and depreciation to debt (ebtodbt) : Measures the amount of cash available to pay down debt
- Change in ROE (chgroe): Change in profitability of a company

$$r_i = \beta_1 * roe_i + \beta_2 * vroe_i + \beta_3 * ebtodbt_i + \beta_4 * chgroe_i \quad (1)$$

Returns to Quality Signal

	Q1	Q2	Q3	Q4	Q5	LS
mean	1.30	1.30	1.21	1.14	1.02	0.28
stdev	5.35	4.72	4.51	4.98	6.81	3.45
median	1.41	1.65	1.57	1.38	1.43	0.25
max	17.40	16.38	17.11	25.00	38.96	15.30
min	(26.68)	(22.39)	(20.24)	(25.85)	(28.63)	(21.55)
stderr	0.25	0.22	0.21	0.24	0.32	0.16
t-stat	5.11	5.80	5.66	4.82	3.15	1.70
NA(%)	0.00	0.00	0.00	0.00	0.00	0.00
pos(%)	0.62	0.64	0.63	0.65	0.63	0.56
neg(%)	0.38	0.36	0.37	0.35	0.37	0.44
q1%	(13.27)	(11.31)	(10.87)	(12.16)	(19.03)	(8.56)
q5%	(7.57)	(6.01)	(5.48)	(6.92)	(10.09)	(4.44)
q25%	(2.00)	(1.51)	(1.53)	(1.53)	(2.01)	(1.33)
q50%	1.41	1.65	1.57	1.38	1.43	0.25
q75%	4.64	4.16	4.06	4.04	4.66	1.91
q95%	9.27	8.35	7.91	8.20	10.47	5.58
q99%	13.79	11.66	11.86	12.40	16.43	11.30
numValid	444.00	444.00	444.00	444.00	444.00	444.00
num	444.00	444.00	444.00	444.00	444.00	444.00
numInf	0.00	0.00	0.00	0.00	0.00	0.00
numNAs	0.00	0.00	0.00	0.00	0.00	0.00
mad	3.30	2.82	2.70	2.82	3.31	1.63
iqr	6.64	5.67	5.60	5.57	6.67	3.24

Returns to Factor Model



Idiosyncratic Return

$$\text{Future Returns} = \beta * \text{Factor Return} + \text{Idiosyncratic Return}$$

Idiosyncratic return (risk) The risk unique to a specific security and independent of market risk. (Also known as specific risk, nonsystematic risk, residual risk, diversifiable risk)

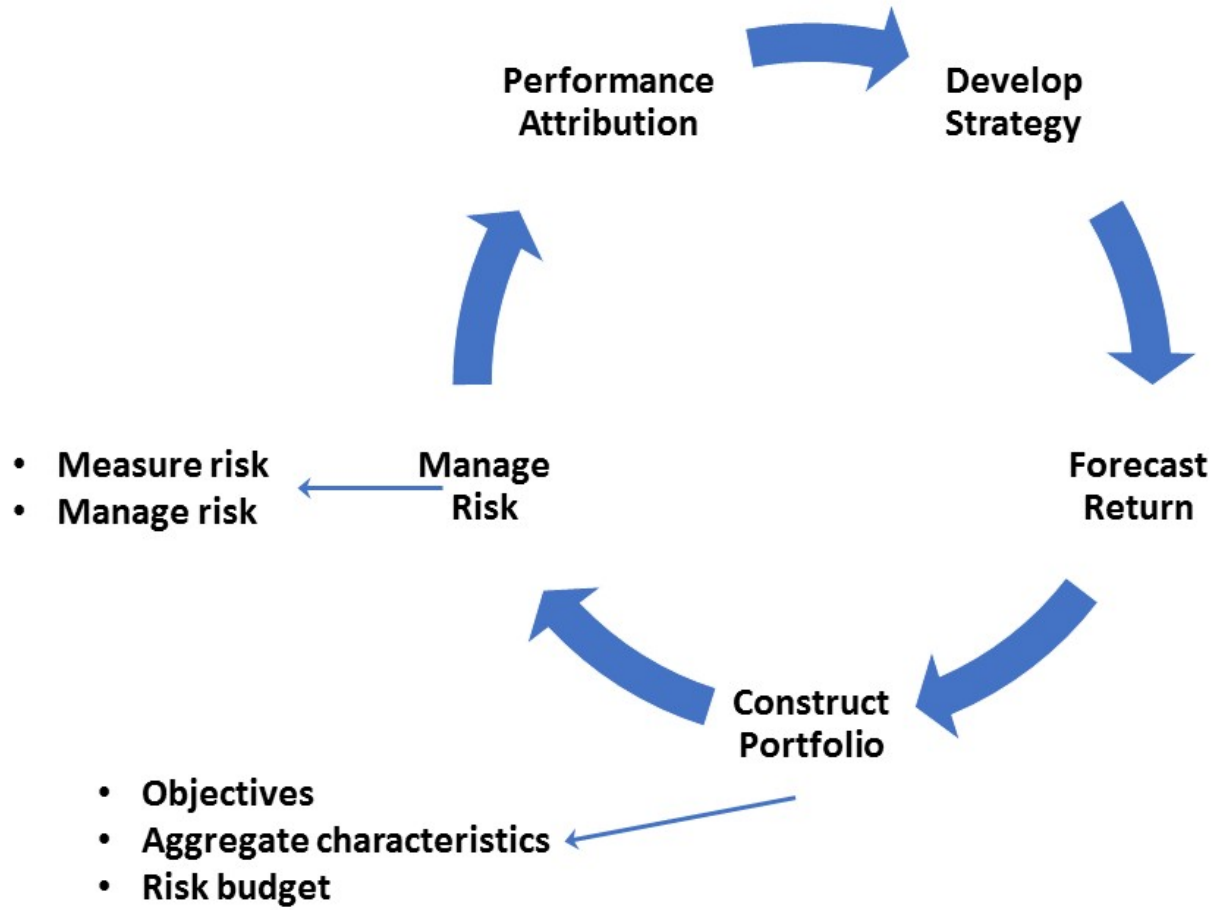
Examples

Stock	Event
Netflix	Successful/unsuccessful TV series
Activision	New profitable/unprofitable video game
Zafgen Bio	Success/failed clinical trials
Volkswagen	Emissions software

Risk to Forecasting Models

- Data-mining
- Structural breaks
- Over-fitting
- Transaction Costs
- Time-variation

Investment Process



Risk Model

$$\text{Returns} = \beta \text{ * Risk Exposure} + \text{Idiosyncratic Return}$$

Risk factors are a common characteristics among a group of assets that is important for explaining risk.

- Magnitude of returns
- Level of uncertainty
- Explains patterns of co-movement

Intuitive, Differentiate, Interesting

Example: Risk Model

Objective: Identify five common risk factors in the returns of stocks

$$r_i = \alpha + \sum_{s=1}^{k} \delta_s f_{i,s} + \beta_s f_{i,ip} + \beta_v f_{i,v} + \beta_g f_{i,g} + \beta_m f_{i,m} + \epsilon_i \quad (2)$$

where for stock i, the factors are

- sector exposure, $f_{i,s} = 1$ if security is in sector s otherwise 0
- industrial production exposure, $f_{i,ip}$
- value exposure, $f_{i,v}$
- growth exposure, $f_{i,g}$
- momentum exposure, $f_{i,m}$

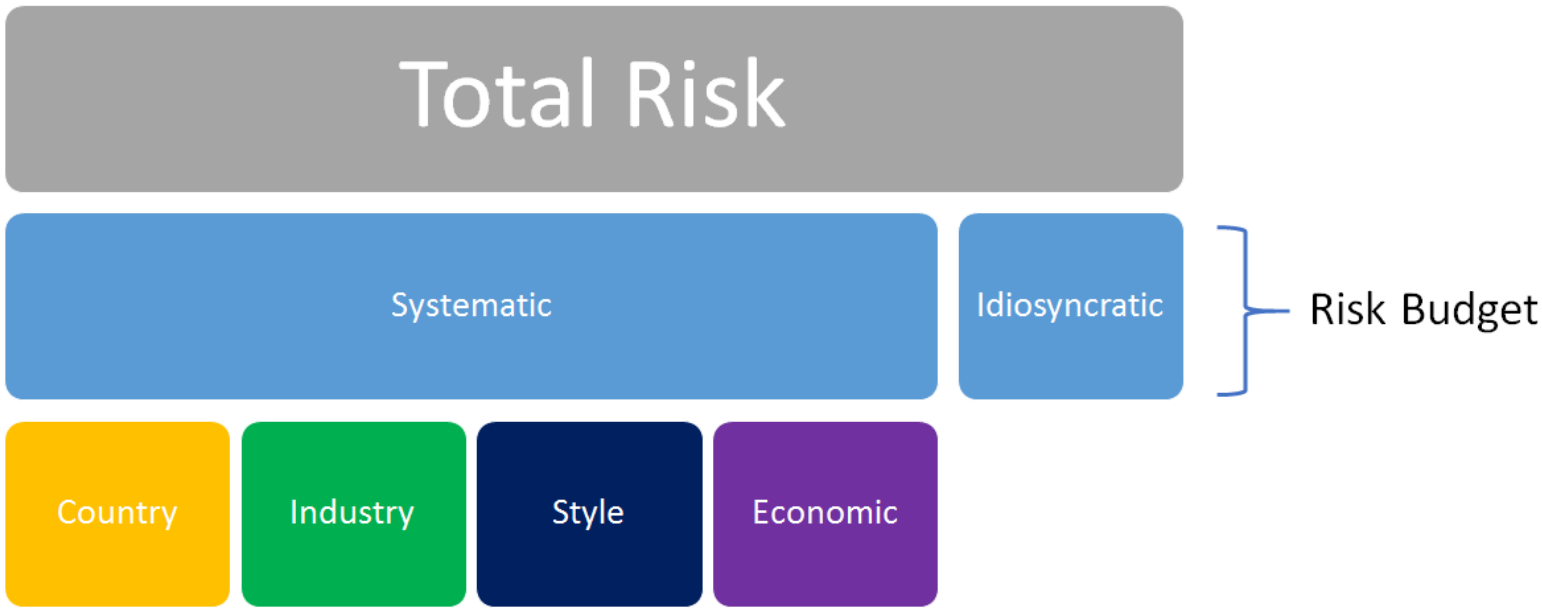
Risk Model

Risk model provides inputs to portfolio construction and risk management:

- Risk exposures for each security
- Covariance matrix
- Estimate of idiosyncratic risk

Risk Budget

The risk model allows us to determine a risk budget



Constructing the optimal portfolio

We can also explicitly model the trade-off between risk and return in the objective function using a risk aversion coefficient, λ.

Objective Function

$$max_w(w' \underbrace{\mu}_{\text{forecasting model}} - \lambda w' \underbrace{\Sigma}_{\text{risk model}} w)$$

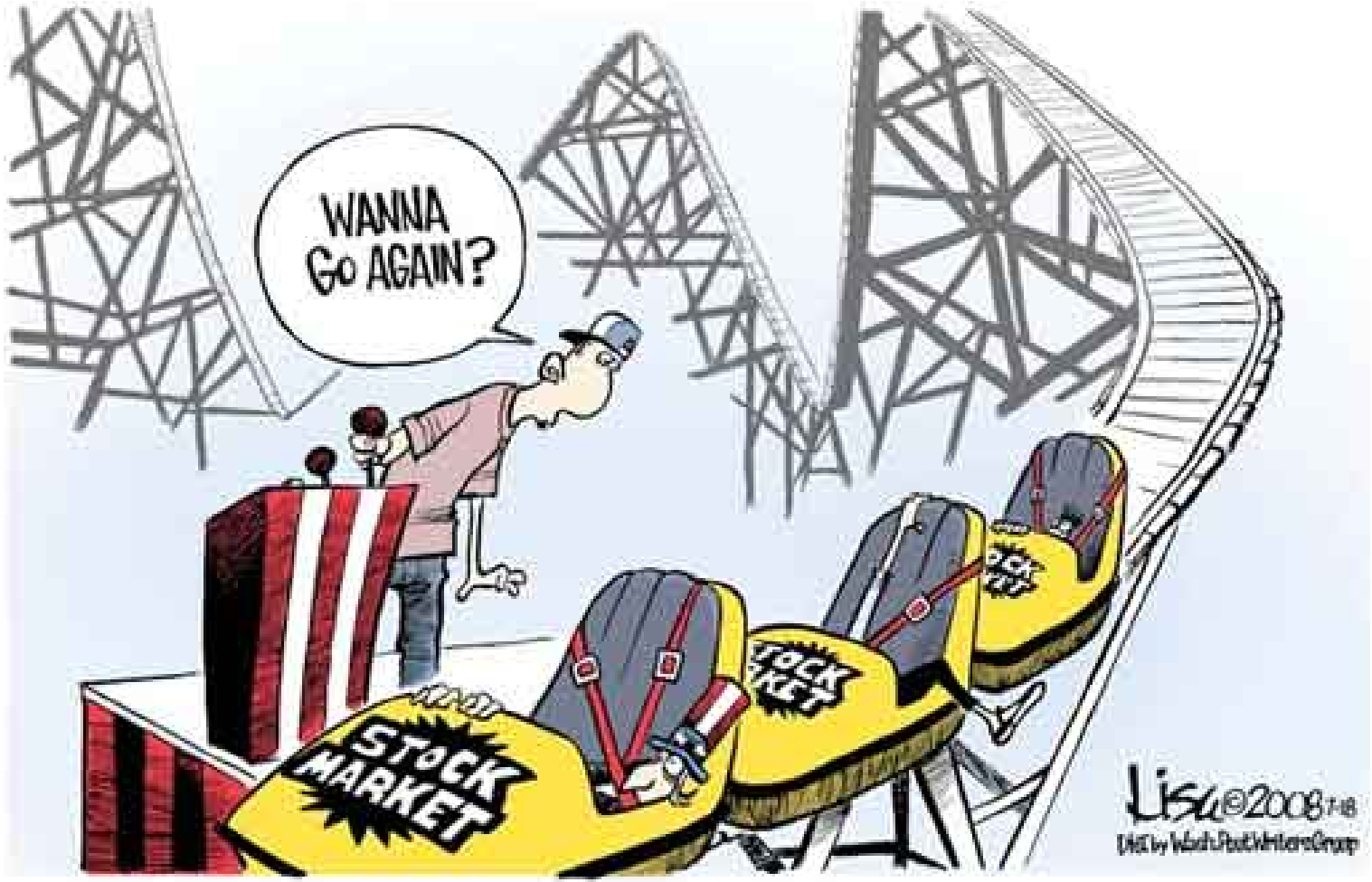
subject to the constraints

$$w'\iota = 1, \iota' = [1, 1, \ldots, 1] \tag{3}$$

and

$$\text{Risk Budget} \tag{4}$$

Risk Management



Risk Management

Portfolio Managers - Provide insight into the risk taking of a portfolio

- What is the overall risk in the portfolio?
- What components make up the overall risk in the portfolio (risk decomposition)?
- How are the component risk related?
- What are the largest risk in the portfolio?
- What are the smallest risk in the portfolio?
- Is the portfolio balancing risk for return?

Factor Models allow us to answer these questions

Performance Attribution

Performance attribution is the process of matching return with the investment decisions (factor/allocation decisions). Factor models provide a framework to measure the factor/allocation decisions.

- Return is attributed to common factors, market timing, and asset selection.
- Using benchmark comparisons to judge performance, the value of each investment decision can be determined.
- Total Return = Allocation Return + Stock Selection Return

Case Study - Applying factor models in portfolio management

Objective: Identify five common risk factors in the returns of stocks

$$r_i = \alpha + \sum_{s=1}^{k} \delta_s f_{i,s} + \beta_s f_{i,ip} + \beta_v f_{i,v} + \beta_g f_{i,g} + \beta_m f_{i,m} + \epsilon_i \quad (5)$$

where for stock i, the factors are

- sector exposure, $f_{i,s} = 1$ if security is in sector s otherwise 0
- industrial production exposure, $f_{i,ip}$
- value exposure, $f_{i,v}$
- growth exposure, $f_{i,g}$
- momentum exposure, $f_{i,m}$

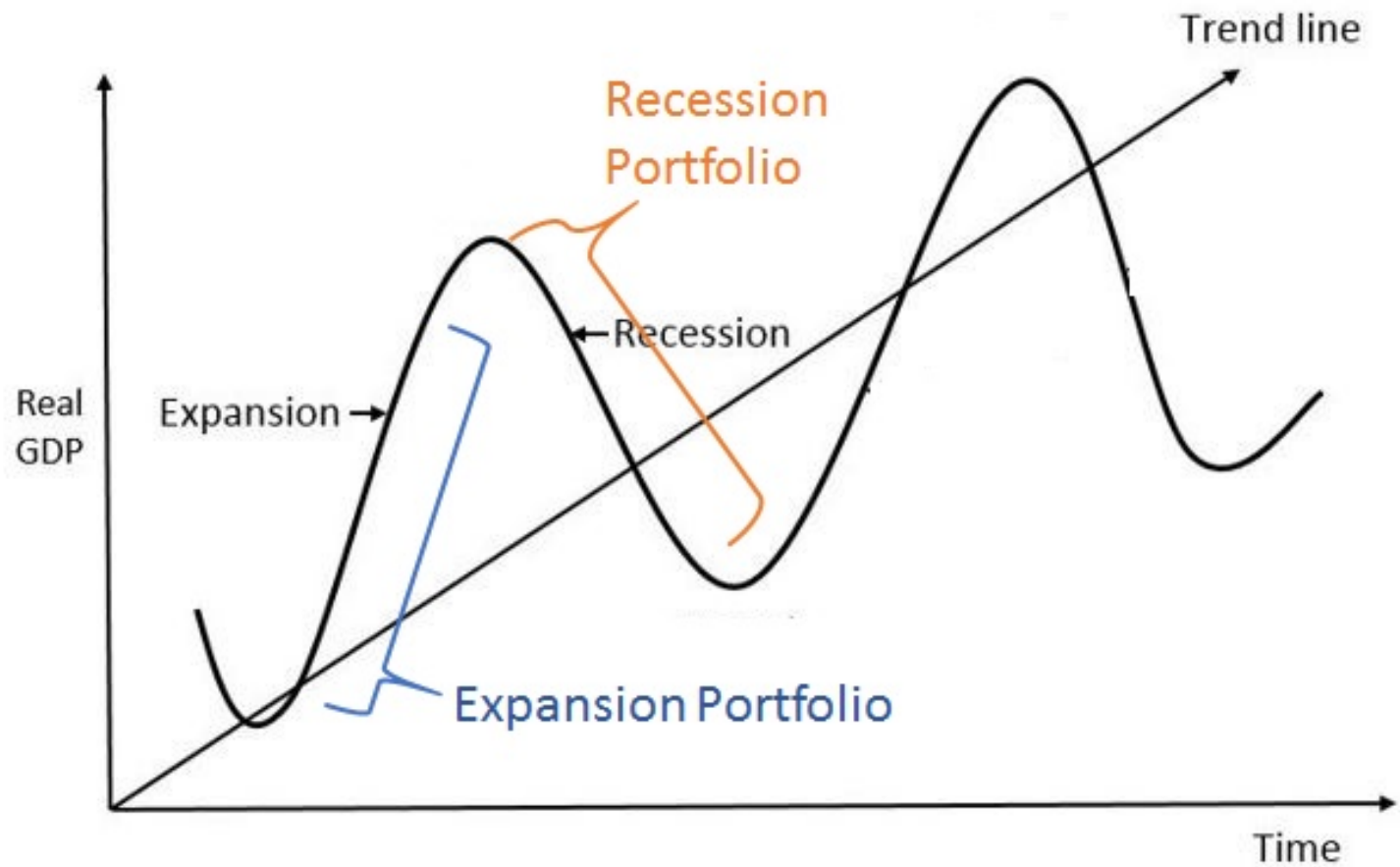
Case Study - Investable Universe

			Risk Model					
			Risk Factors					
Stock	Weight	Sector	Industrial Production	Value	Growth	Momentum	Idiosyncratic Risk	BETA
Ford	8.3%	Consumer Discretionary	1.0	3.0	1.0	(2.0)	5.8%	1.05
NetFlix	8.3%	Consumer Discretionary	0.0	(3.0)	3.0	3.0	9.2%	1.70
Walmart	8.3%	Consumer Staples	(3.0)	1.0	(1.0)	(1.0)	4.5%	0.80
Burlington Stores	8.3%	Consumer Staples	2.0	(2.0)	1.0	2.0	5.7%	1.10
Wells Fargo	8.3%	Financials	0.0	2.0	(1.0)	(1.0)	5.7%	0.92
Merck	8.3%	Healthcare	(1.0)	2.0	0.0	1.0	4.5%	0.95
CSX	8.3%	Industrials	2.0	0.0	1.0	(1.0)	3.7%	1.10
Deere	8.3%	Industrials	2.0	1.0	(1.0)	(1.0)	8.7%	1.17
Dupont	8.3%	Materials	3.0	1.0	(2.0)	(1.0)	6.1%	1.15
Rouse Prop	8.3%	Real Estate	2.0	(2.0)	(1.0)	2.0	3.5%	1.00
Microsoft	8.3%	Technology	1.0	(1.0)	2.0	1.0	5.6%	1.05
American Elect Power	8.3%	Utilities	(1.0)	(1.0)	(1.0)	1.0	3.8%	0.70
Portfolio Wgt Average	**100.0%**		**0.7**	**0.1**	**0.1**	**0.3**	**5.6%**	**1.06**

Risk Budget for Portfolio

Case Study

Build portfolios to outperform in the expansion phase and recession phase of the business cycle



Case Study

Portfolio Positioning

- Expansion Portfolio
  - High Industrial Production Exposure
  - High Value Exposure
  - Neutral Growth Exposure
  - Low Momentum Exposure
  - High Market Beta
- Recession Portfolio
  - Low Industrial Production Exposure
  - Low Value Exposure
  - Neutral Growth Exposure
  - High Momentum Exposure
  - Low Market Beta

Case Study

Expansion Portfolio

					Risk Factors					
Stock	New Weight	Old Weight	Trades	Sector	Industrial Production	Value	Growth	Momentum	Idiosyncratic Risk	BETA
Ford	17.5%	8.3%	9.2%	Consumer Discretionary	1.0	3.0	1.0	(3.0)	5.8%	1.05
CSX	17.5%	8.3%	9.2%	Industrials	2.0	3.0	1.0	(2.0)	3.7%	1.10
Deere	17.5%	8.3%	9.2%	Industrials	2.0	2.0	(1.0)	(2.0)	8.7%	1.17
Dupont	17.5%	8.3%	9.2%	Materials	3.0	2.0	(2.0)	(2.0)	6.1%	1.15
Burlington Stores	10.0%	8.3%	1.7%	Consumer Staples	2.0	(2.0)	1.0	2.0	5.7%	1.10
Rouse Prop	10.0%	8.3%	1.7%	Real Estate	2.0	(2.0)	(1.0)	2.0	3.5%	1.00
Microsoft	10.0%	8.3%	1.7%	Technology	0.0	(1.0)	2.0	1.0	5.6%	1.05
NetFlix	0.0%	8.3%	(8.3%)	Consumer Discretionary	0.0	(3.0)	3.0	3.0	9.2%	1.70
Walmart	0.0%	8.3%	(8.3%)	Consumer Staples	(3.0)	1.0	(1.0)	(1.0)	4.5%	0.80
Wells Fargo	0.0%	8.3%	(8.3%)	Financials	0.0	2.0	(1.0)	(1.0)	5.7%	0.92
Merck	0.0%	8.3%	(8.3%)	Healthcare	(1.0)	2.0	0.0	1.0	4.5%	0.95
American Elect Pow	0.0%	8.3%	(8.3%)	Utilities	(1.0)	(1.0)	(1.0)	1.0	3.8%	0.70
New Portfolio Total					**1.8**	**1.3**	**0.0**	**(1.1)**	**5.7%**	**1.10**
Prv Portfolio Total					**0.7**	**0.1**	**0.1**	**0.3**	**5.6%**	**1.06**
Difference					**1.1**	**1.2**	**(0.1)**	**(1.3)**	**0.0**	**0.04**

Case Study

Recession Portfolio

					Risk Factors					
	New	Old			Industrial				Idiosyncratic	
Stock	Weight	Weight	Trades	Sector	Production	Value	Growth	Momentum	Risk	BETA
Walmart	25.0%	8.3%	16.7%	Consumer Staples	(3.0)	1.0	(1.0)	(1.0)	4.5%	0.80
Merck	25.0%	8.3%	16.7%	Healthcare	(1.0)	2.0	0.0	1.0	4.5%	0.95
American Elect Pow	20.0%	8.3%	11.7%	Utilities	(1.0)	(1.0)	(1.0)	1.0	3.8%	0.70
Microsoft	10.0%	8.3%	1.7%	Technology	0.0	(1.0)	2.0	1.0	5.6%	1.05
NetFlix	10.0%	8.3%	1.7%	Consumer Discretionary	0.0	(3.0)	3.0	3.0	9.2%	1.70
Rouse Prop	5.0%	8.3%	(3.3%)	Real Estate	2.0	(2.0)	(1.0)	2.0	3.5%	1.00
Burlington Stores	5.0%	8.3%	(3.3%)	Consumer Staples	2.0	(2.0)	1.0	2.0	5.7%	1.10
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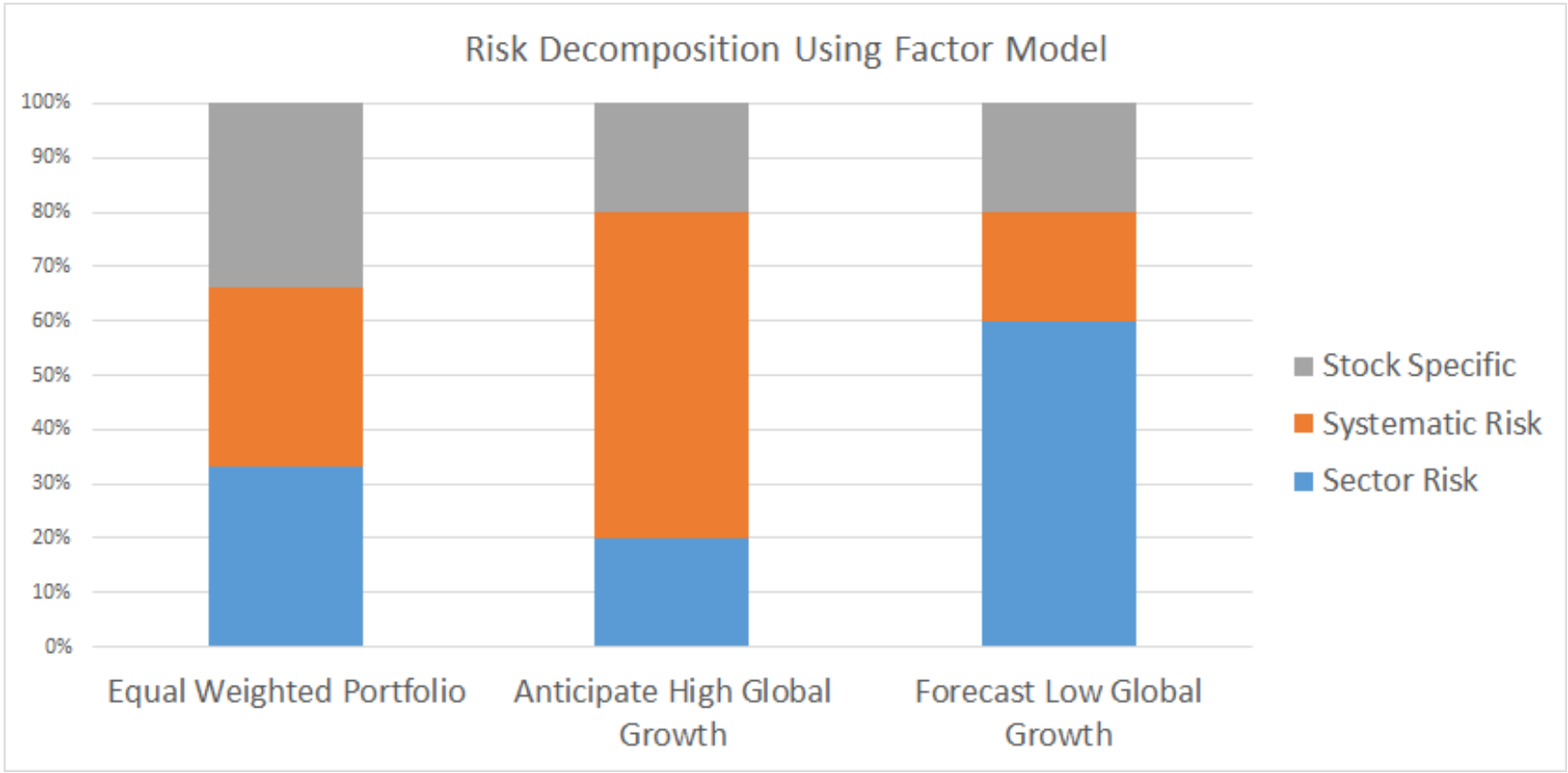
Deere	0.0%	8.3%	(8.3%)	Industrials	2.0	2.0	(1.0)	(2.0)	8.7%	1.17
Portfolio Total	**100.0%**	**100.0%**			**(1.0)**	**(0.1)**	**0.1**	**0.8**	**4.9%**	**0.96**
Prv Portfolio Total					**0.7**	**0.1**	**0.1**	**0.3**	**5.6%**	**1.06**
Difference					**(1.7)**	**(0.1)**	**(0.0)**	**0.6**	**(0.0)**	**(0.10)**

Risk Decomposition



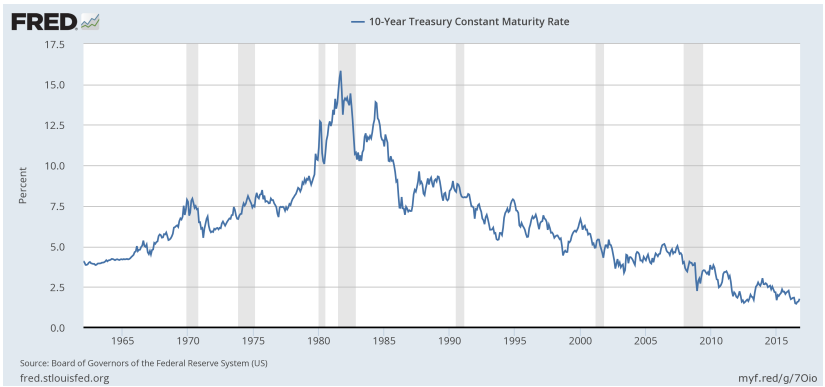
Challenges to the efficacy of factor models

- Market conditions
- Rising correlation level
- Central Bank Policy
- Geopolitical
- Style rotation
- Insufficient liquidity
- Fundamental market shift
- Non-trending markets
- Nonlinearity

Source: Kolm and Cerniglia (2011)

Challenges: Quest for Income

- Bond yields are low
- Monetary Policy influences yields
- Investors in need of income look to the stock market
- Moving the prices for high yielding stocks such as REITs, Defensive Stocks



Current Industry Trends

- Alternative Data
  - Website scraping
  - Credit card tracking
  - Geolocation
  - Satellite imagery
- Natural Language Processing
- Machine Learning
  - AI/Deep Learning
- Optimal Collaboration of Man and Machine
- Decision Science

Source: FT:Hedge funds see a gold rush in data mining

Summary

- Building and using factor models is a science and an art
- Understand the motivation and assumptions of a factor model
- Factor models provide an edge in making investment decisions