Indexes

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Lesson Plan

Learning Outcomes

- Discuss the two standard methods to construct standard market indexes.
- Describe the similarities and differences of an index and its ETF.
- Compute the dollar amount allocated and the number of shares needed for each component stock.
- Discuss the role of a divisor.
- Compute the new divisor when a component stock has corporate actions.
- Define and describe smart beta indexes and their ETFs.

Preamble to Standard Market Indexes

- Stock market index was essentially created as a **barometer** to gauge market movement or sentiment.
- Charles H. Dow, a journalist, had an idea of a stock price average to reflect the stock market condition.
- After two years of experimentation in the Customer's Afternoon Letter, the Dow Jones Transportation Index (called the "Railroad Average" in the past) made its debut on July 3, 1884, **the oldest index in history still in use**.
- Dow's indexing **algorithm**:
  1. Formulate selection criteria
  2. Select 9 railroads, a steamship company, and a telegraph company
  3. Record their end-of-day stock prices
  4. Compute the **average price** as the index (probably by hand)

Price Weighted Method

- Suppose the number of component stocks is N.
- At time t, the prices of component stocks are $P_{i,t}$, $i = 1, 2, \ldots, N$.
- Sum up all the prices to obtain the total price P_t:

$$P_t = \sum_{i=1}^{N} P_{i,t}.$$

- Given current total price P_t, the current index I_t is calculated as

$$I_t = \frac{P_t}{P_{t-1}} I_{t-1}.$$

- It can be rewritten as $I_t = \frac{P_t}{\frac{P_{t-1}}{I_{t-1}}}$, and $D := \frac{P_{t-1}}{I_{t-1}} = \frac{P_t}{I_t}$ is the **divisor** for the index.

How to Construct a Price-Weighted Index?

- Example

Company	3M Co.	Boeing Co.	Intel Corp.	Pfizer Inc.
Last Price	$241.14	$320.26	$42.50	$36.47

- What is the index level at inception?
- What is the divisor at inception?

ETF on Price-Weighted Index

- Equal number of shares for every component stock!
- One **round lot** is usually 100 shares.

Company	3M Co.	Boeing Co.	Intel Corp.	Pfizer Inc.
Last Price	$241.14	$320.26	$42.50	$36.47
Shares	100	100	100	100
Cost	$24,114.00	$32,026.00	$4,250.00	$3,647.00
Fees	$4.95	$4.95	$4.95	$4.95
Total	$24,118.95	$32,030.95	$4,254.95	$3,651.95

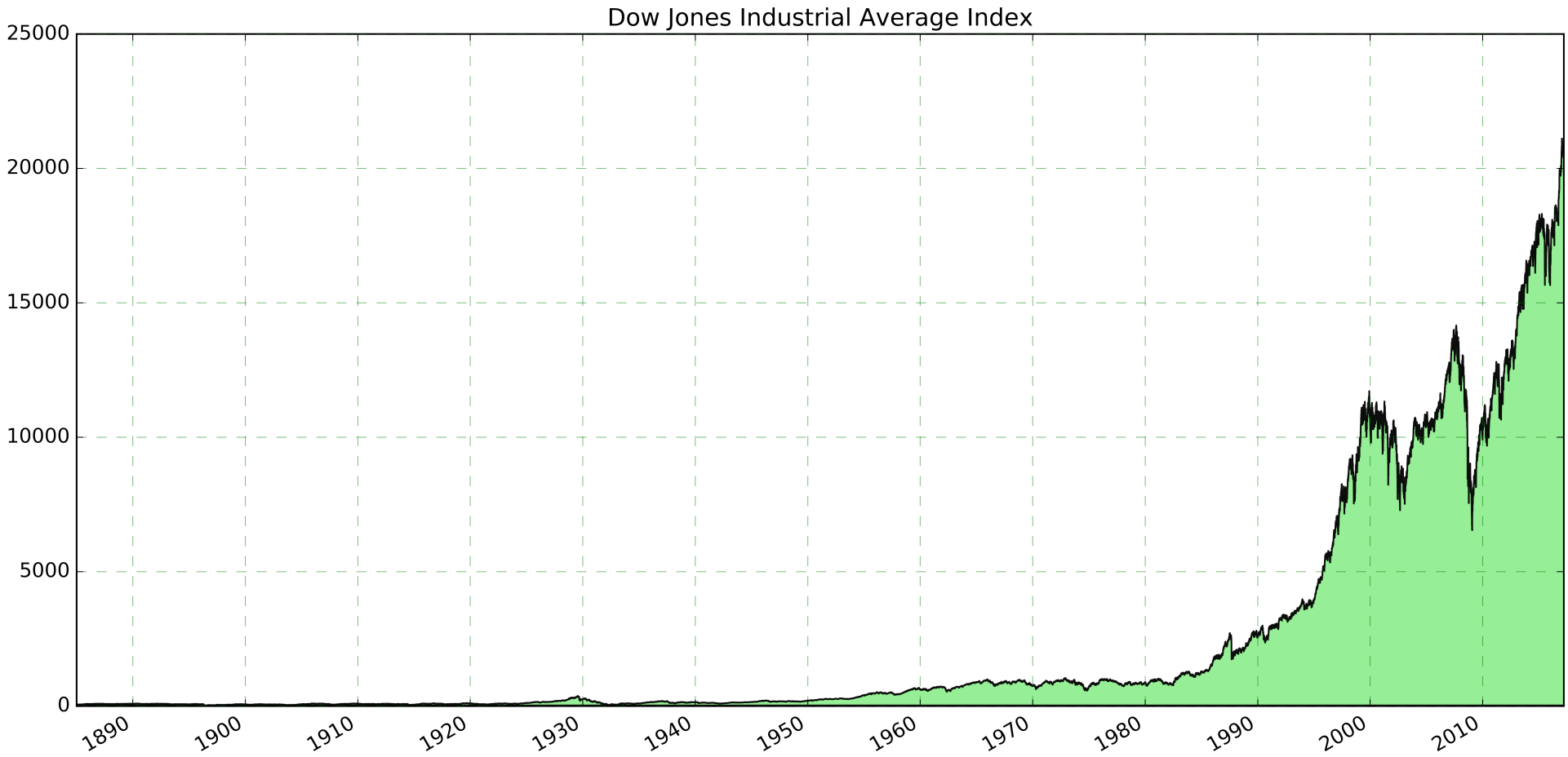
- You must have at least $64,056.80 to construct the ETF.

Dow Jones Industrial Average

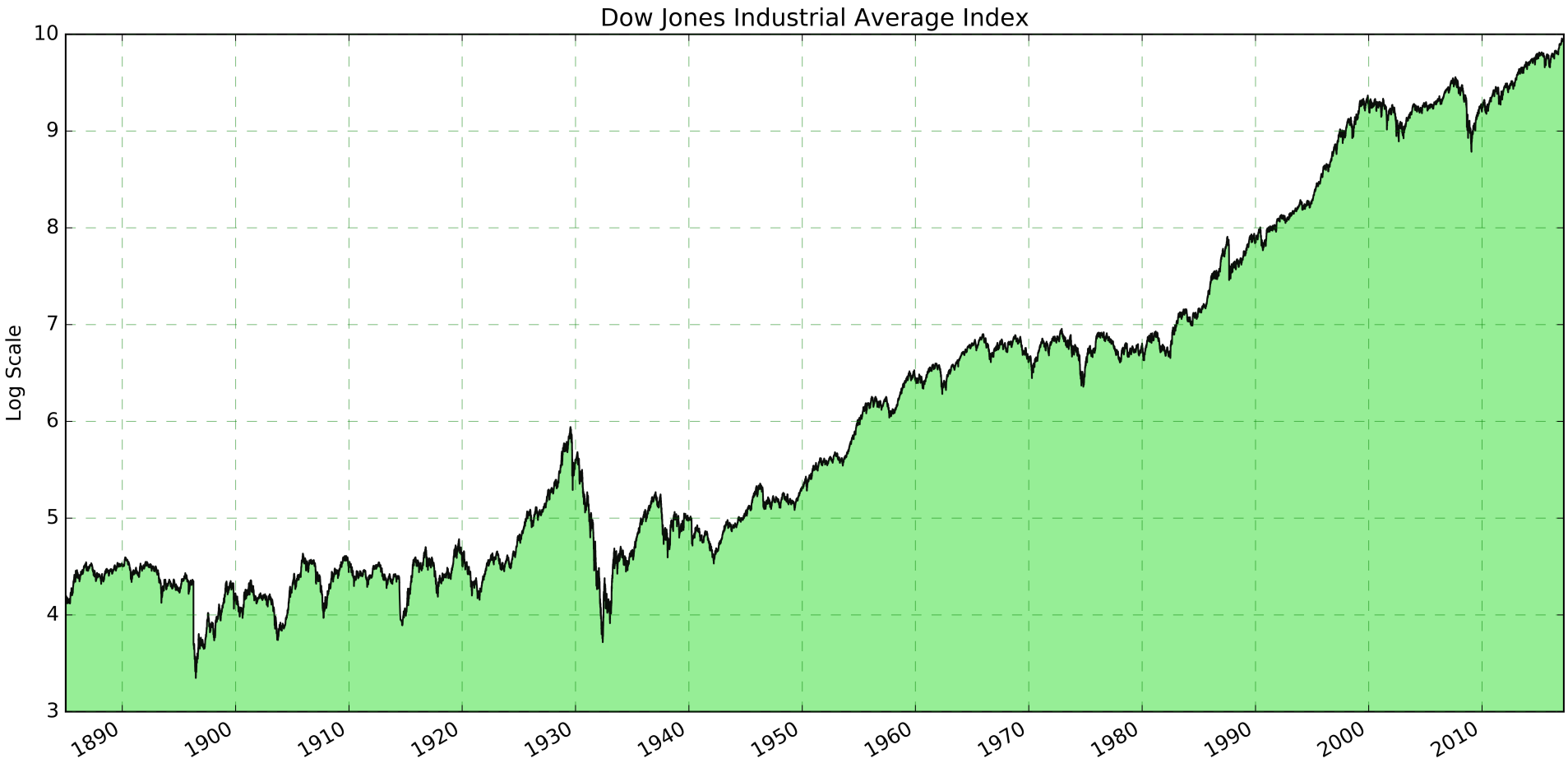
- Dow selected 12 industrial stocks and published the Industrial Average from May 26, 1896.
- At the onset of World War I, New York Stock Exchange (NYSE) shut down on July 31, 1914, due to large selling by foreigners (Europeans).
- On December 12, 1914, NYSE re-opened.
- On October 4, 1916, 20 component stocks were introduced.
- On October 1, 1928, several innovations were introduced. First, the list was expanded from 20 to 30. Second, a divisor was introduced. Third, Dow Jones began calculating the high-low-close for the component stocks.

Reference: **Global Financial Data**

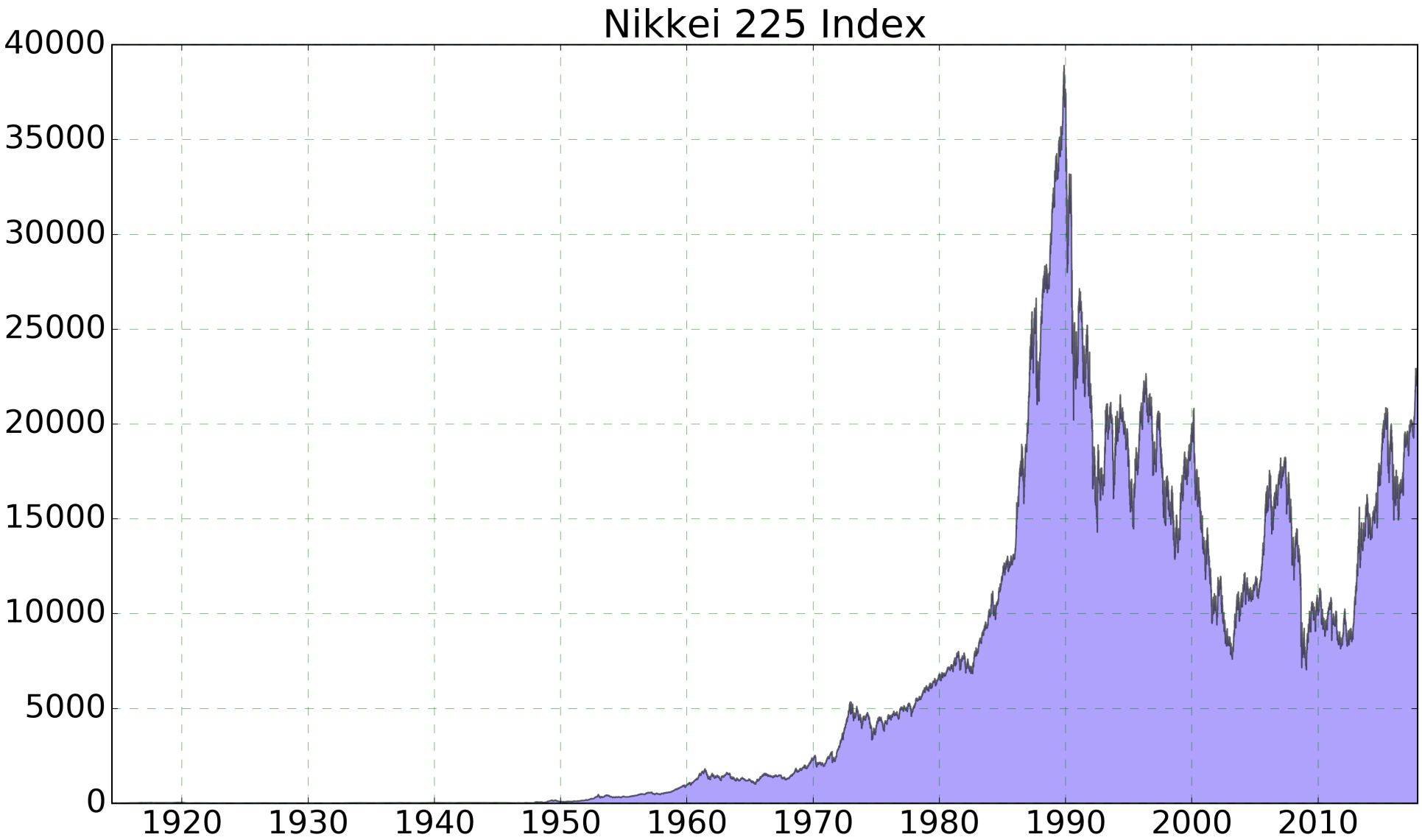
Historical Plot of DJIA Index



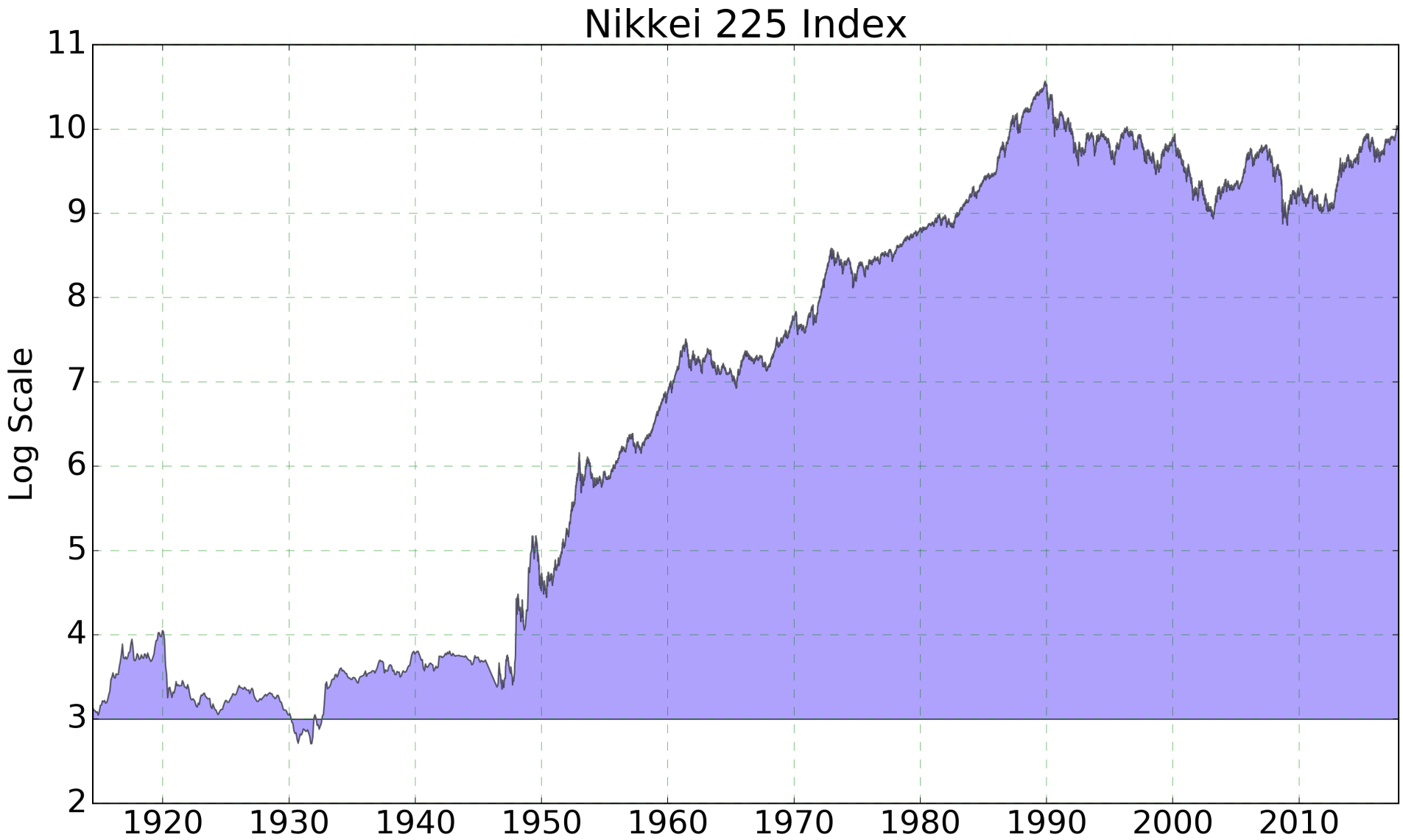
Historical Plot of DJIA Index in Log Scale



Historical Plot of Nikkei 225 Index



Historical Plot of Nikkei 225 Index in Log Scale



Free Float Adjusted Market Capitalization

- Number of free float shares last updated at time s, $\tilde{S}_{i,s}$, for each stock i must be known.
- Free float adjusted market capitalization of component stock i is $M_{i,t} = P_{i,t}\tilde{S}_{i,s}$.
- Total free float adjusted market cap is

$$M_t = \sum_{i=1}^{N} M_{i,t}.$$

- Given current total (free float adjusted) market capitalization M_t, the current index I_t is calculated as

$$I_t = \frac{M_t}{M_{t-1}} I_{t-1} = \frac{M_t}{\frac{M_{t-1}}{I_{t-1}}} = \frac{M_t}{D},$$

where D is the **divisor**.

How to Construct a Market Cap-Weighted Index?

Company	3M Co.	Boeing Co.	Intel Corp.	Pfizer Inc.
Last Price	$241.14	$320.26	$42.50	$36.47
Free Float	594,932,300	560,908,700	4,678,276,000	5,958,174,000
Mkt Cap	$143,461,974,822	$179,636,620,262	$198,826,730,000	$217,294,605,780
Weight	19.41%	24.30%	26.90%	29.40%

- Total market cap is $739,219,930,864.
- To start the index at the level of 100, the divisor should be set at 7,392,199,308.64.

Market Cap-Weighted Index ETF

Company	3M Co.	Boeing Co.	Intel Corp.	Pfizer Inc.
Last Price	$241.14	$320.26	$42.50	$36.47
Free Float	594,932,300	560,908,700	4,678,276,000	5,958,174,000
Mkt Cap	$143,461,974,822	$179,636,620,262	$198,826,730,000	$217,294,605,780
Weight	19.41%	24.30%	26.90%	29.40%
$ Alloted	$19,407.21	$24,300.84	$26,896.83	$29,395.12
Shares	80.48	75.88	632.87	806.01
Rounded	100	100	600	800
Cost	$24,114.00	$32,026.00	$25,500.00	$29,176.00
Fees	$4.95	$4.95	$4.95	$4.95
Total	$24,118.95	$32,030.95	$25,504.95	$29,180.95

- Start with $100,000 to “try out”.
- Eventual total cost is $110,835.80.
- ETFs, being institutional, are able to acquire odd lot with low cost.

Examples of Market Cap Weighted Indexes

- Most stock market indexes are free-float market cap weighted.
- S&P 500 Index
- **S&P Dow Jones Indices**
- Topix Index
- Hang Seng Index
- **MSCI** indexes
- **FTSE-Russell indexes**

Remarks on Standard Indexes

- Based on prices directly
- Self-rebalancing
- Rebalancing due to corporate actions
- **Stock split** of a component stock: price-weighted index must change the divisor; market cap weighted index need not change.
- **Shares buy-back** and **recapitalization** of a component stock: price-weighted index is not affected; market cap weighted index must change the divisor.

How to Change the Divisor?

- **The basic principle is that the index value should not change when adjusting the divisor after the market has closed.**
- For price-weighted index I_t, suppose Stock 1 has a stock split.

$$I_t = \frac{\sum_{i=1}^{N} P_{i,t}}{D_{\text{old}}} = \frac{P'_{1,t} + \sum_{i=2}^{N} P_{i,s_i}}{D_{\text{new}}}.$$

- For free float market cap weighted index J_t, suppose stock 1 has a recapitalization: S_{1,s_i} becomes $S'_{1,t}$. Then

$$J_t = \frac{\sum_{i=1}^{N} P_{i,t} S_{i,s_i}}{D_{\text{old}}} = \frac{P_{1,t} S'_{1,t} + \sum_{i=2}^{N} P_{i,t} S_{i,s_i}}{D_{\text{new}}}.$$

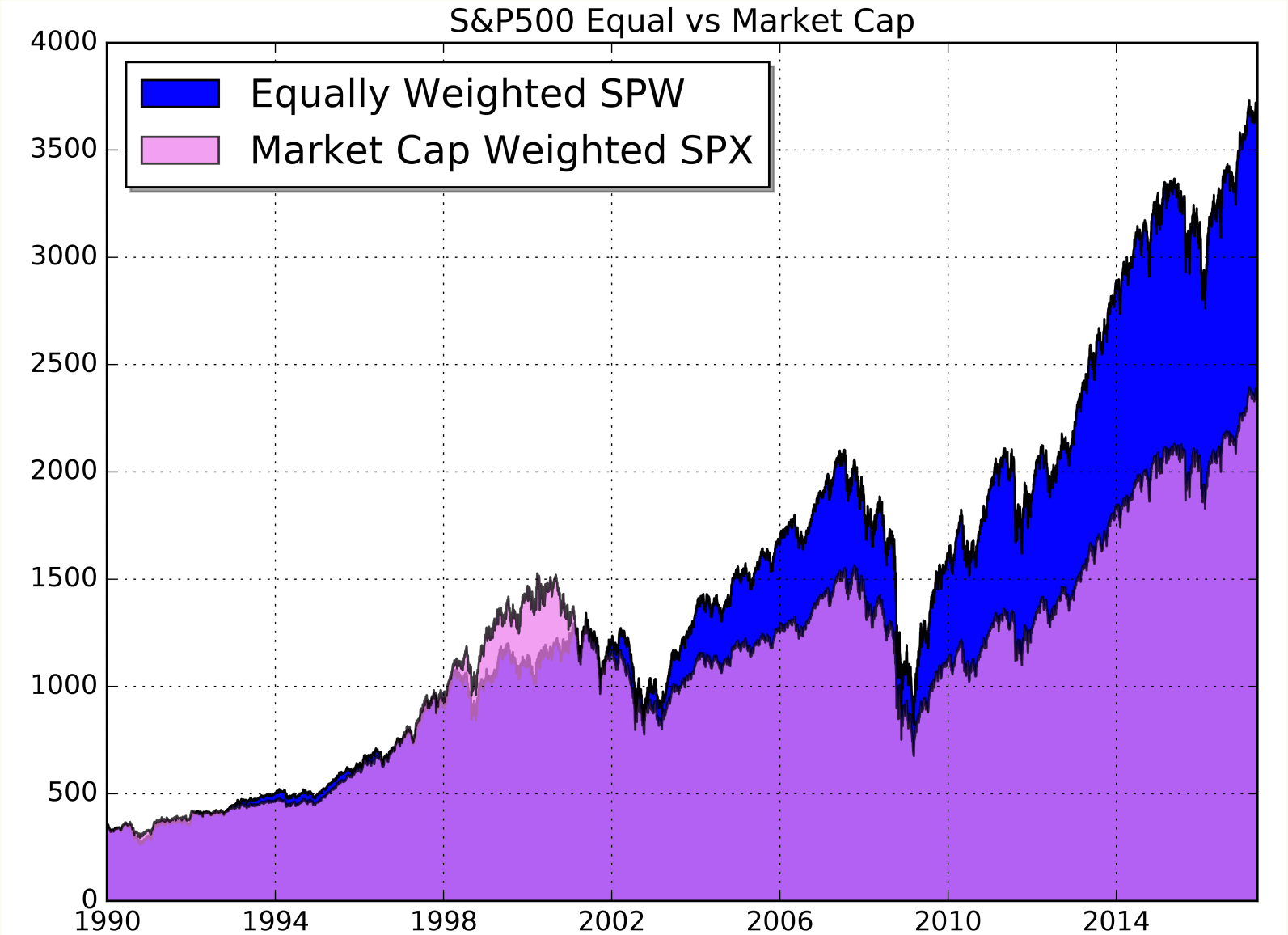
Overview of Alternatively Weighted Indexes

- Alternative weighted indexes are not based on prices directly.
- They are designed to reflect the performance of investment strategies with specific diversification, risk reduction, or factor objectives.
- Alternative weighting schemes include
  - Equal
  - Fundamental
  - Minimum variance
  - Factor

Equally Weighted

- An equally weighted index weighs each stock equally regardless of its market capitalization or economic value (sales, earnings, book value).
- But the portfolio must be constantly re-balanced so that each stock is equally weighted again.
- What are the implications of frequent re-balancing?

Equally Weighted vs Market Cap Weighted



How to Construct an Equally Weighted Index?

- Since index is not meant to be traded, the number of shares can have decimals.

Company	3M Co.	Boeing Co.	Intel Corp.	Pfizer Inc.
Last Price	$241.14	$320.26	$42.50	$36.47
Weight	25.00%	25.00%	25.00%	25.00%
$ Alloted	$25,000	$25,000	$25,000	$25,000
Shares	103.67	78.06	588.24	685.49

- Total hypothetical dollars alloted is $100,000 in this example.
- To start at the index level of 100, the divisor is set at 1,000.

Equally Weighted Index ETF

- You have $100,000 and "try out" allocating $25,000 to each stock.

Company	3M Co.	Boeing Co.	Intel Corp.	Pfizer Inc.
Last Price	$241.14	$320.26	$42.50	$36.47
Weight	25.00%	25.00%	25.00%	25.00%
$ Alloted	$25,000.00	$25,000.00	$25,000.00	$25,000.00
Shares	103.67	78.06	588.24	685.49
Rounded	100	100	600	700
Cost	$24,114.00	$32,026.00	$25,500.00	$25,529.00
Fees	$4.95	$4.95	$4.95	$4.95
Total	$24,118.95	$32,030.95	$25,504.95	$25,533.95

- The total cost is $107,188.80

Fundamentally Weighted Index

- A fundamentally weighted index is constructed by calculating the economic size of each company within the index's universe, based on such factors as: revenues; cash flow; book value; and dividends. The index is then weighted to reflect the relative economic size of each stock to the overall universe.
- Examples
  - Last Year's Earnings of Stocks, A, B, and C are, respectively, $900 million, $600 million, and $300 million.
  - So the weights are, respectively, 50%, 33.33%, and 16.67%.
- Since the index weights are not based on market cap, it is not influenced by short term elements.

Reference: http://valueweightedindex.com/

Fundamental Indexation

Reading: **Robert D. Arnott, Jason Hsu, and Philip Moore, Financial Analysts Journal 61, 83–99 (2005)**

Table: Performances of Fundamentally Weighted Indexes, 1962-2004

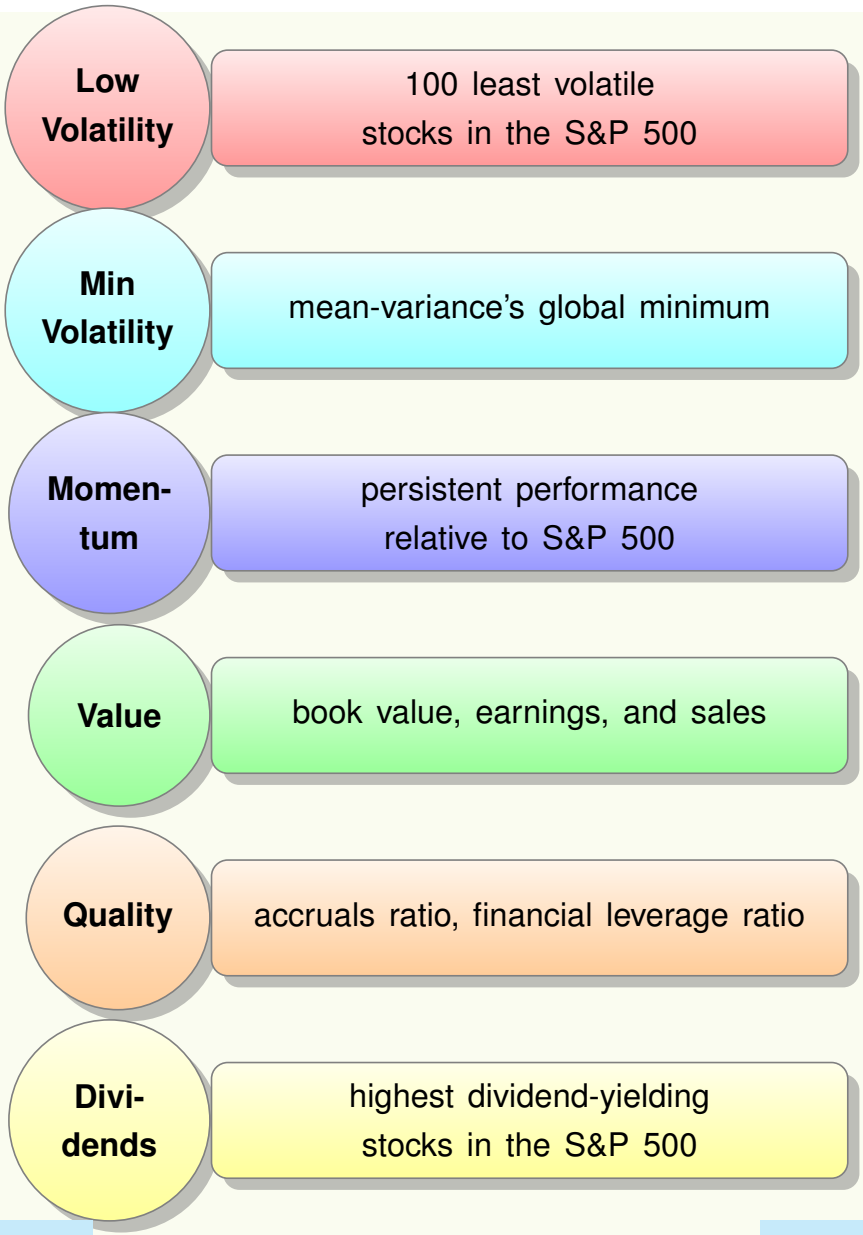
Portfolio/ Index	Ending Value of $1	Geometric Return	Volatility	Sharpe Ratio	Excess Return	Tracking Error	Information Ratio	t-Statistic for Excess Return
Reference	$68.95	10.35%	15.2%	0.301	–	–	–	–
S&P 500	$73.98	10.53%	15.1%	0.315	0.18%	1.52%	0.12	0.76
Book	$136.22	12.11%	14.9%	0.426	1.76%	3.54%	0.50	3.22
Income	$165.21	12.61%	14.9%	0.459	2.26%	3.94%	0.57	3.72
Revenue	$182.05	12.87%	15.9%	0.448	2.52%	5.03%	0.50	3.25
Sales	$184.95	12.91%	15.8%	0.452	2.56%	4.93%	0.52	3.36
Dividends	$131.37	12.01%	13.6%	0.458	1.66%	5.33%	0.31	2.02
Employment	$156.83	12.48%	15.9%	0.423	2.13%	4.64%	0.46	2.98
Average	$159.44	12.50%	15.2%	0.444	2.15%	4.57%	0.47	3.09
Composite	$156.54	12.47%	14.7%	0.455	2.12%	4.21%	0.50	3.26

The Reference portfolio is a market cap-weighted index of 1,000 component stocks.

Smart Beta

- The origin of alternatively weighted indexes is the idea of “smart beta”.
- A definition of smart beta
  Smart beta is a type of transparent investment strategies that are based on **rules** designed to **provide** specific exposure to certain risk factors or/and market segments.
- In implementing a smart beta investment strategy, you would systematically select, weigh, and re-balance portfolio holdings on the basis of factors or characteristics other than market capitalization.
- The equity factors that appear to be most robust over time and across countries are company size, value, low volatility, momentum, quality, dividends, and share buybacks.

S&P 500 Smart Beta Indices

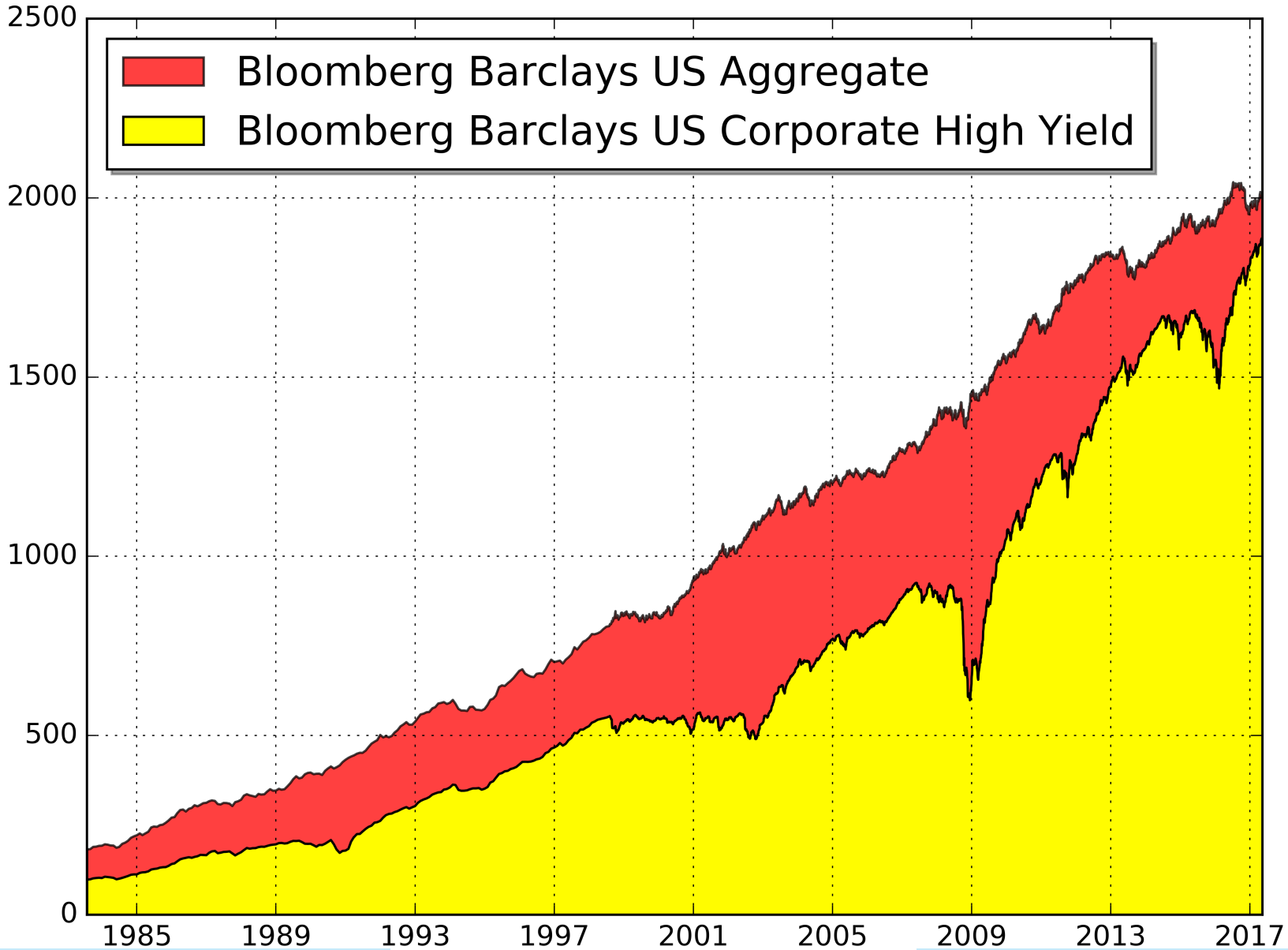


Summary Statistics of S&P 500 Smart Beta

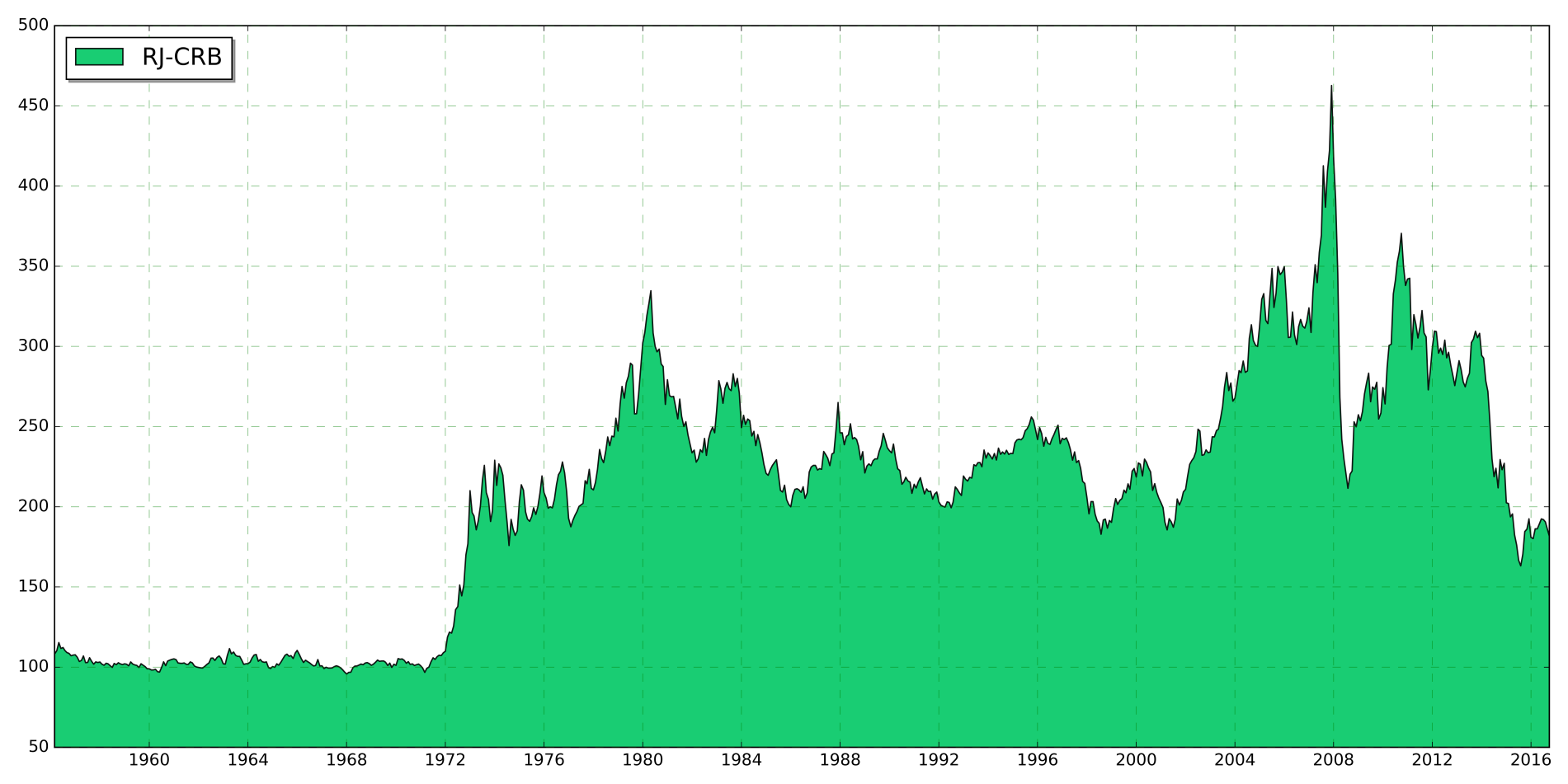
Sample Period: Dec 31, 2001 through Dec 31, 2016. Reference: **Factoring in Factors, S&P Dow Jones Indices**

	Equal Weight	Enhanced Value	Low Volatility	Momentum	Quality	Dividend Aristocrats	Buyback	S&P 500
Performance								
Return (%)	9.29	7.82	9.13	7.21	9.21	9.71	10.90	6.69
Volatility (%)	16.97	19.65	10.30	14.11	13.55	12.90	16.00	14.35
Sharpe Ratio	0.47	0.33	0.77	0.42	0.59	0.66	0.60	0.38
Sortino Ratio	0.83	0.57	1.34	0.74	1.04	1.17	1.04	0.67
Performance Relative to S&P 500								
Monthly Alpha (%)	0.14	(0.00)	0.39	0.13	0.24	0.32	0.32	
Beta to Market	1.15	1.26	0.61	0.85	0.92	0.83	1.05	
Beta to Up Market	1.20	1.22	0.51	0.69	0.96	0.93	1.07	
Beta to Down Market	1.13	1.38	0.71	0.81	0.92	0.83	1.09	
Correlation	0.97	0.92	0.85	0.86	0.97	0.92	0.94	
Extreme Risk Statistics								
Best Monthly (%)	18.7	22.0	6.8	11.5	10.5	12.2	16.3	10.9
Worst Monthly (%)	(21.1)	(23.5)	(12.8)	(14.0)	(16.3)	(13.2)	(21.2)	(16.8)
+ ve Monthly (%)	62.8	61.7	62.8	64.4	65.0	64.4	63.3	64.4
Drawdown History								
Max Drawdown (%)	(54.9)	(67.9)	(35.4)	(44.0)	(44.4)	(44.1)	(53.0)	(50.9)
Peak Date	07-May	07-May	07-May	07-Oct	07-Oct	07-May	07-May	07-Oct
Trough Date	09-Feb	09-Feb	09-Feb	09-Feb	09-Feb	09-Feb	09-Feb	09-Feb
Peak to Trough	21	21	21	16	16	21	21	16
Recovery Length	23	50	22	37	24	20	23	37

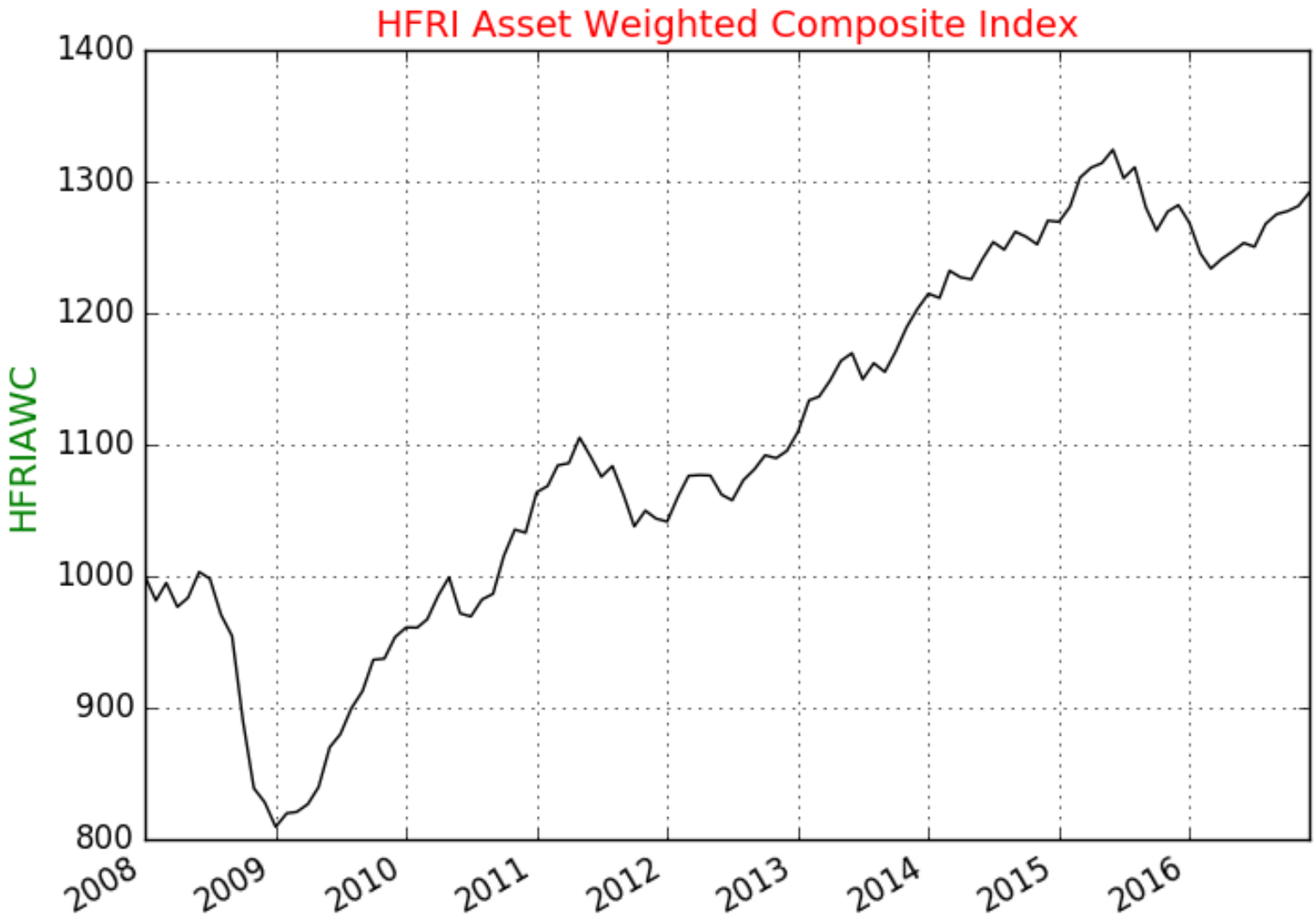
Bond Indices



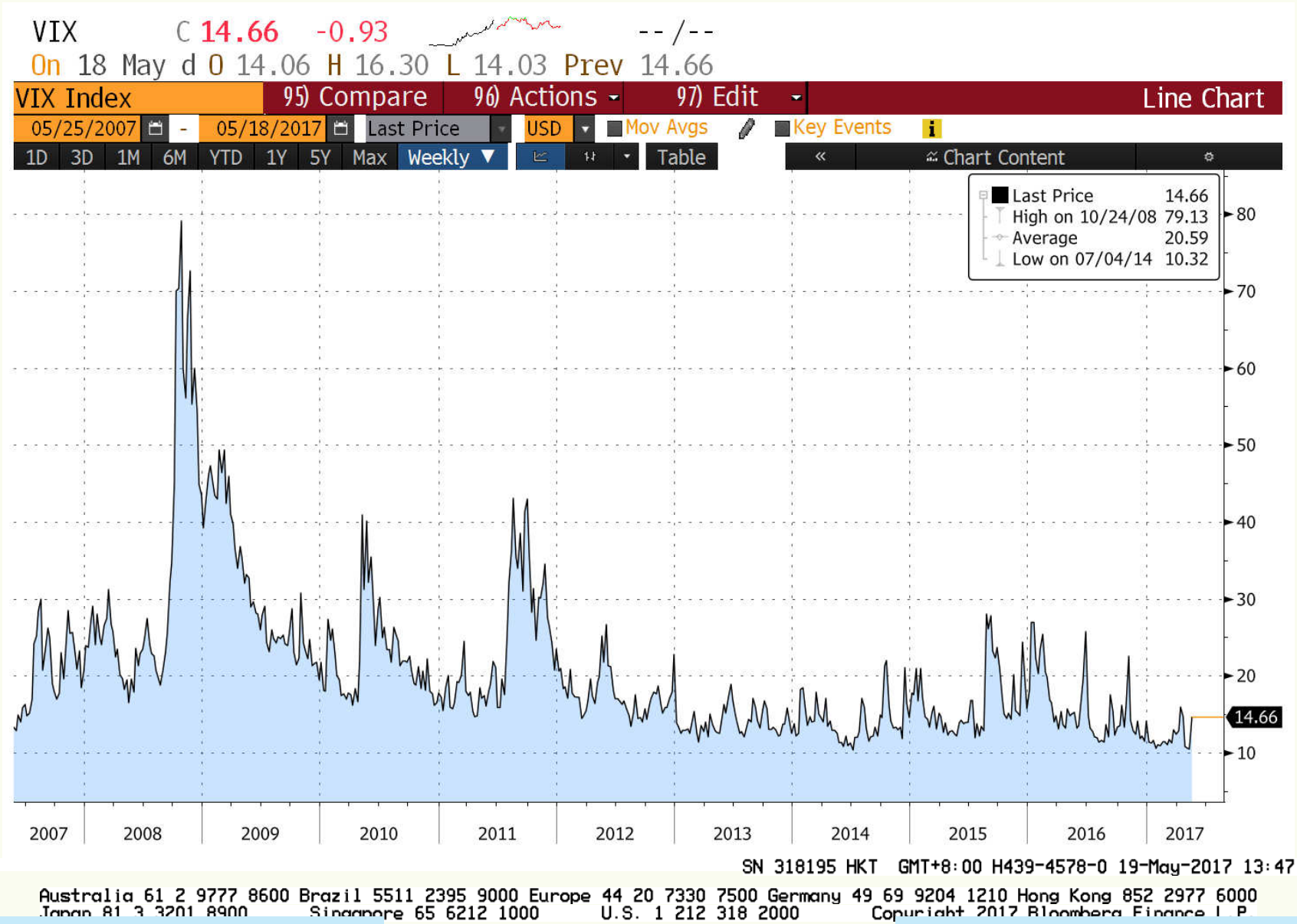
Reuters/Jefferies-CRB Index



Hedge Fund Index



Volatility Index (VIX)



Deutsche Bank Index Quant Group's Credit Index

DBIQ is responsible for launching, daily calculation, rebalancing, and retiring of proprietary Deutsche Bank benchmarks.

Markit Indices

97) Settings — CDS Index Monitor

Data Range: Spread — 3 Months

Markit Indices	Spread	Change Spread	Basis	Roll	Low	Range (Avg / Now)	High	Avg	+/-	3M Chg
1) Americas										
10) CDX Investment Grade	64.74	-1.08	-35.2	8.3	60.1		69.9	64.7	+0.0	+1.0
11) CDX High Yield	107.16*	+0.08	-7.0	-0.6	106.5		108.2	107.4	-0.2	-0.4
12) MCDX	57.50	+1.00		3.5	56.5		74.0	69.0	-11.5	-16.5
13) CDX Latin America										
2) EMEA										
20) iTraxx Europe	65.19	+1.38	-159.5	7.1	62.0		77.5	71.5	-6.3	-9.1
21) iTraxx HIVOL	29.66	+0.62		7.6	29.0		41.0	34.6	-5.0	-9.9
22) iTraxx Crossover	260.76	+4.24	18.3	24.9	249.8		301.1	282.2	-21.4	-38.6
23) iTraxx Sr Financial	71.90	+0.89	-164.3	7.0	66.5		95.9	85.0	-13.1	-21.4
24) iTraxx Sub Financial	165.13	+4.29	-87.4	12.8	149.8		226.5	195.6	-30.5	-59.4
25) iTraxx Corp CEEMEA	165.62	+3.27		17.0	162.3		204.4	178.9	-13.3	-37.1
26) iTraxx SOVX W Europe	11.02	+0.65		-2.7	9.9		25.3	16.0	-5.0	-13.5
27) iTraxx SOVX CEEMEA	58.79	+5.26		12.1	48.3		73.5	59.1	-0.3	-13.7
3) Asia										
30) iTraxx Japan	44.00	-0.15	-29.0	-6.6	43.2		54.4	47.6	-3.6	-10.1
31) iTraxx Asia Ex Japan IG	93.27	-1.48	-124.7	13.9	87.1		103.6	96.1	-2.8	-9.3
32) iTraxx Australia	85.18	-0.01	6.4	12.4	80.8		91.5	85.2	+0.0	-3.4
Emerging Markets										
40) CDX Emerging Market	95.20*	+0.00	2.0	-1.1	94.5		95.9	95.1	+0.1	+0.7

*These securities are price quoted.

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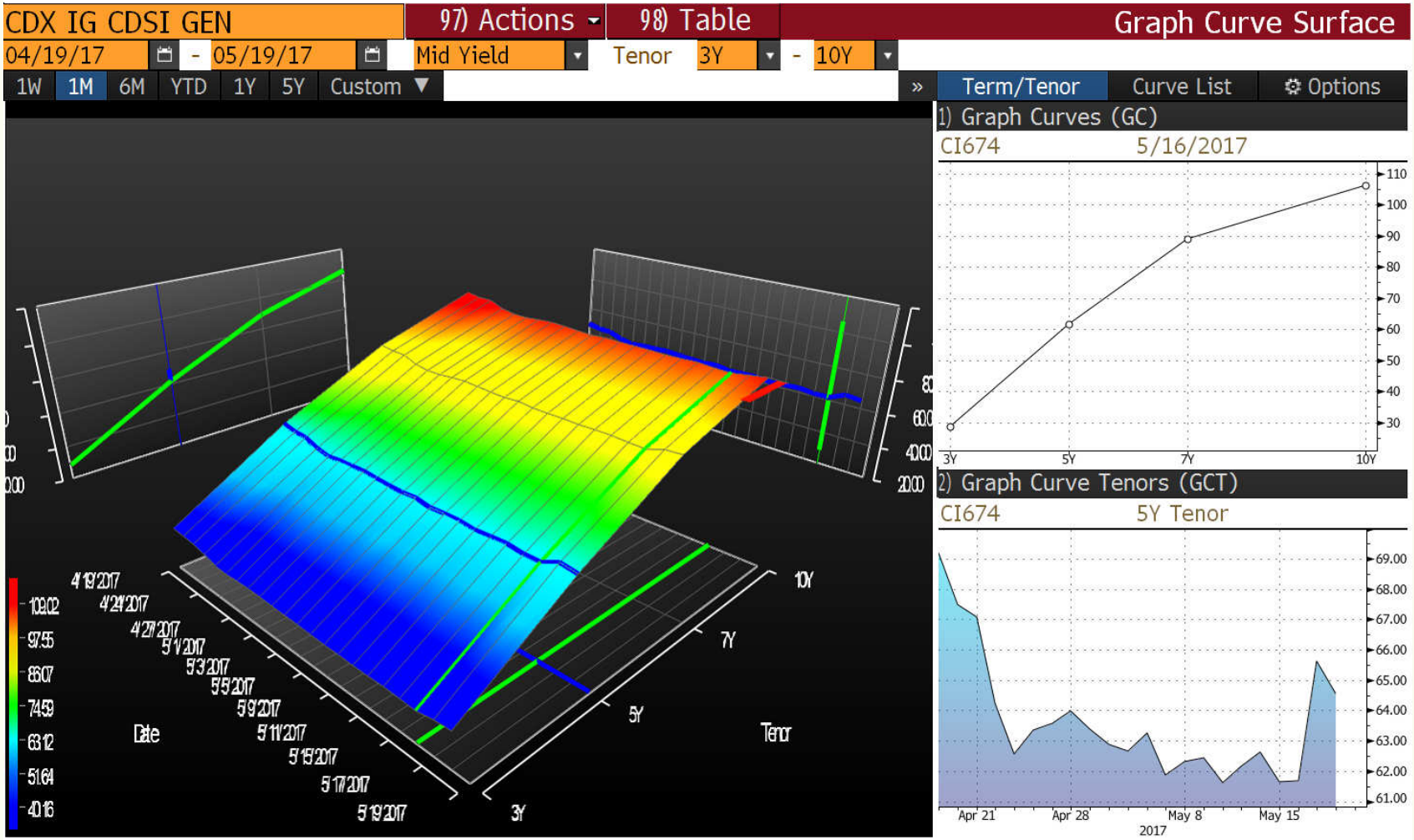
Investment Grade



High Yield


CDX HY CDSI GEN 5Y PRC 107.115 +0.111 107.081/107.149
At 18 May Source CBBT
CDX HY CDSI GEN 5Y PRC Corp
Page 1/2 Description: CDS Index
94) Notes
95) Buy
96) Sell
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Pages
1) Index Info
2) Roll Info
Index Information
Markit CDX North America High Yield Index is composed of 100 non-investment grade entities, distributed among 2 sub-indices: B, BB. All entities are domiciled in North America. Markit CDX indices roll every 6 months in March & September.
Contract Information
Currency USD Day Cnt ACT/360
Tenor 5Y Cpn Freq Q
Dsc Curv US Fixing Swap Curve
Region America
ISDA Definitions Year 2014
Cpn (bps) 500 Factor 1.0
Recovery 0.30 Version 1
Quote Type Price Series 28
Start Date 03/20/17 Start Cnst 100
Mty Date 06/20/22
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Identifiers
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Full Name CDX HY CDSI GEN 5Y PR
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Takeaways

- Index weighing methods are investment strategies.
- Both standard and alternative equity market indexes are paper portfolios that assume zero market friction.
  1. Stock trading is ideally liquid; no price impact in trading
  2. Number of shares can be in decimals; arbitrary positive real numbers
  3. No commission and fees in construction, re-balancing, and reconstitution
- ETF of an equity index has market friction.
- Most smart beta indexes seem to be superior than the S&P 500 index in terms of Sharpe ratio.
- Many indexes for other asset classes