SMART BETA FUND

Team Members - Sadhana Jayakumar, Samarth C Swamy, Surya Kaushik
Project Mentor - Rohit Handique

ABSTRACT

Most stock market indexes these days follow a market capitalization-weighted methodology to calculate its value from each stock and the Capital Asset Pricing model to choose individual securities. The problem behind this is that - if a single company attains a really large market cap (like blue-chip companies) then the value of the index would follow the behavior of this particular stock and not be a good representation of the complete market. This problem is solved by fundamentally weighted indexes, which we will be building with stocks selected from the publicly available large-cap stocks in Indian Stock Exchanges. Fundamental indexes attempt to outperform classic benchmarks by screening securities based upon various financial measures. Some of these metrics include sales, book value, cash flow, valuation, and even dividends. We will also be analyzing the performance of our index fund with other major index funds in India.

INTRODUCTION

A mutual fund is a type of financial vehicle made up of a pool of money collected from many investors to invest in securities like stocks, bonds, money market instruments, and other assets. Mutual funds are operated by professional money managers, who allocate the fund's assets and attempt to produce capital gains or income for the fund's investors. A mutual fund's portfolio is structured and maintained to match the investment objectives stated in its prospectus.

Mutual funds give small or individual investors access to professionally managed portfolios of equities, bonds, and other securities. Each shareholder, therefore, participates proportionally in the gains or losses of the fund. Mutual funds invest in a vast number of securities, and performance is usually tracked as the change in the total market cap of the fund—derived by the aggregating performance of the underlying investments.

Mutual funds pool money from the investing public and use that money to buy other securities, usually stocks and bonds. The value of the mutual fund company depends on the performance of the securities it decides to buy. So, when you buy a unit or share of a mutual fund, you are buying the performance of its portfolio or, more precisely, a part of the portfolio's value. Investing in a share of a mutual fund is different from investing in shares of stock. Unlike stock, mutual fund shares do not give their holders any voting rights. A share of a mutual fund represents investments in many different stocks (or other securities) instead of just one holding.

A market index is a hypothetical portfolio of investment holdings that represents a segment of the financial market. The calculation of the index value comes from the prices of the underlying holdings. Some indexes have values based on market-cap weighting, revenue-weighting, float-weighting, and fundamental-weighting. Weighting is a method of adjusting the individual impact of items in an index.

A market index measures the value of a portfolio of holdings with specific market characteristics. Each index has its own methodology which is calculated and maintained by the index provider. Index methodologies will typically be weighted by either price or market cap. A wide variety of investors use market indexes for following the financial markets and managing their investment portfolios. Indexes are deeply entrenched in the investment management business with funds using them as benchmarks for performance comparisons and managers using them as the basis for creating investable index funds.

"Indexing" is a form of passive fund management. Instead of a fund portfolio manager actively stock picking and market timing—that is, choosing securities to invest in and strategizing when to buy and sell them—the fund manager builds a portfolio whose holdings mirror the securities of a particular index. The idea is that by mimicking the profile of the index—the stock market as a whole, or a broad segment of it—the fund will match its performance as well.

Fig: Few Major Indexes in India and the World

Each index has its own method for calculating the index's value. Weighted average mathematics is primarily the basis for index calculations as values are derived from a weighted average calculation of the value of the total portfolio. As such, price-weighted indexes will be more greatly impacted by changes in holdings with the highest price, while market capitalization-weighted indexes will be most greatly impacted by changes in the largest stocks, and so on, depending on the weighting characteristics.

Our fund is a passively managed fundamentally weighted fund i.e. an index fund whose individual stocks are being selected based on a thorough analysis of the fundamental values and then weighted based on their market cap multiplied by a fundamental factor.

KEY TAKEAWAYS

1. A mutual fund is a type of investment vehicle consisting of a portfolio of stocks, bonds, or other securities.
2. Mutual funds give small or individual investors access to diversified, professionally managed portfolios at a low price.
3. Market indexes provide a broad representative portfolio of investment holdings.
4. Methodologies for constructing individual indexes vary but nearly all calculations are based on weighted average mathematics.
5. Indexes are used as benchmarks to gauge the movement and performance of market segments.
6. An index fund is a portfolio of stocks or bonds designed to mimic the composition and performance of a financial market index.
7. Index funds follow a passive investment strategy.
8. Actively managed funds have fund managers selecting and reshuffling the individual securities in the fund while passively managed funds reshuffle annually or half-yearly.

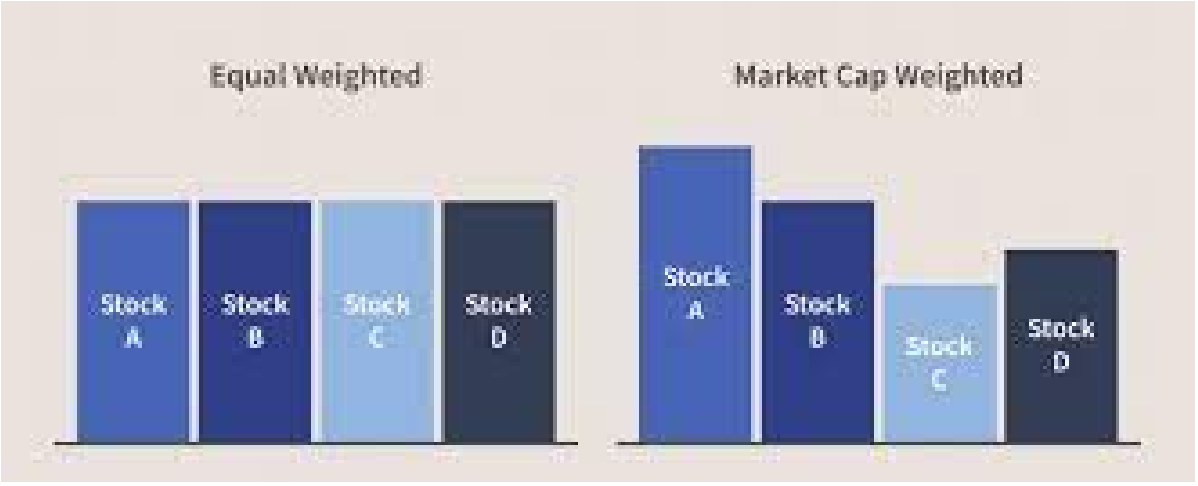
THE PROBLEM

This makes sense to most people; Apple is ~twenty times larger than eBay and therefore it should have twenty times the weighting. But is size all that matters? Is there a better way to construct an index? A way that puts less faith in the size of a company and more faith in its “economic footprint?

The commonly available index funds are formed based on the Capital Asset Pricing Model. Basically, CAPM assumes that cash flows can be determined into the future on every investment. This helps to identify the true value of each security. Because the market is efficient, it will properly match the asset's price to its CAPM-determined value. The efficient market theory states that a stock's price reflects the market's best estimates of the firm's underlying true value at any given time. According to the EMH, stocks always trade at their fair value on exchanges, making it impossible for investors to purchase undervalued stocks or sell stocks for inflated prices.

But what if the price ends up above or below the "true value"? Does this mean the true value is wrong? Not necessarily, instead, it means that each security will trade above or below its ultimate true value. If every security is trading above or below its true value, then capitalization-weighted indices will be overexposed to securities trading above their true fair values and underexposed to assets trading below their true fair values.

If investors put more of their money in securities that are above fair value and less money in securities below fair value, they will get a lower return. It also means that the capitalization-weighted indices generate returns below what is possible. In a capitalization-weighted index, every stock that is overvalued is overweighted, while those that are undervalued are underweighted.



Here's an example to help explain the performance of a capitalization-weighted index compared to, say, an equal-weight index. In an equal-weight index, it is even odds whether the overvalued stock will be over-or under-bought. Equal weighting under-weights every stock that is large, regardless of whether it's expensive, and over-weights each stock that is small, regardless of whether it's expensive.

Suppose there are only two stocks in the market and, according to CAPM, each has a true value of $1,000. One stock is estimated by the market to be worth $500, while for the other the market places a value of $1,500. The capitalization-weighted index would place 25% of the total portfolio in the undervalued stock and 75% of the total portfolio in the overvalued stock. The equal-weighted index requires that an investor place the same amount in each stock in his or her portfolio. In other words, each stock would comprise 50% of the portfolio regardless of whether it is overvalued or undervalued.

Five years later, the valuation errors are corrected, and both stocks come to be valued at $1,000. In this case, if you had based your portfolio on a capitalization-weighted index, your return would be zero. On the other hand, an investor who placed her money in the equal-weighted index would experience a return of 33.5%. The lower-priced stock would earn $1,000 for the portfolio, while the higher-priced stock would lose $330 for the portfolio. The table below presents this example.

	Year 1		Year 5		
	Cap-weighted	Equal-weighted	Cap-weighted	Equal-weighted	% gain (loss)
Stock A	$ 1,500	$ 1,000	$ 1,000	$ 670	-33.0%
Stock B	$ 500	$ 1,000	$ 1,000	$ 2,000	100.0%
	$ 2,000	$ 2,000	$ 2,000	$ 2,670	33.5%

This is where fundamentally weighted indices offer an alternative. "Fundamental Indexation," a study released in 2005 by Rob Arnott, Jason Hsu, and Phillip Moore, argued that fundamentally weighted indices outperformed the S&P 500, a traditional capitalization-weighted index, by approximately 2% per year for the 43 years of the study. The fundamental factors used in the study were book value, cash flow, revenue, sales, dividends, and employment.

While a 2% difference might seem insignificant when compounded it doubles the size of an investor's portfolio in 35 years. Clearly, this represents a better return compared to traditional capitalized-weighted returns. Keep in mind that studies show that many mutual funds underperform the overall market. Therefore, where investors place their long-term investments makes a real difference over the years, although this backtesting did not include the impact of fees and taxes.

THE SOLUTION

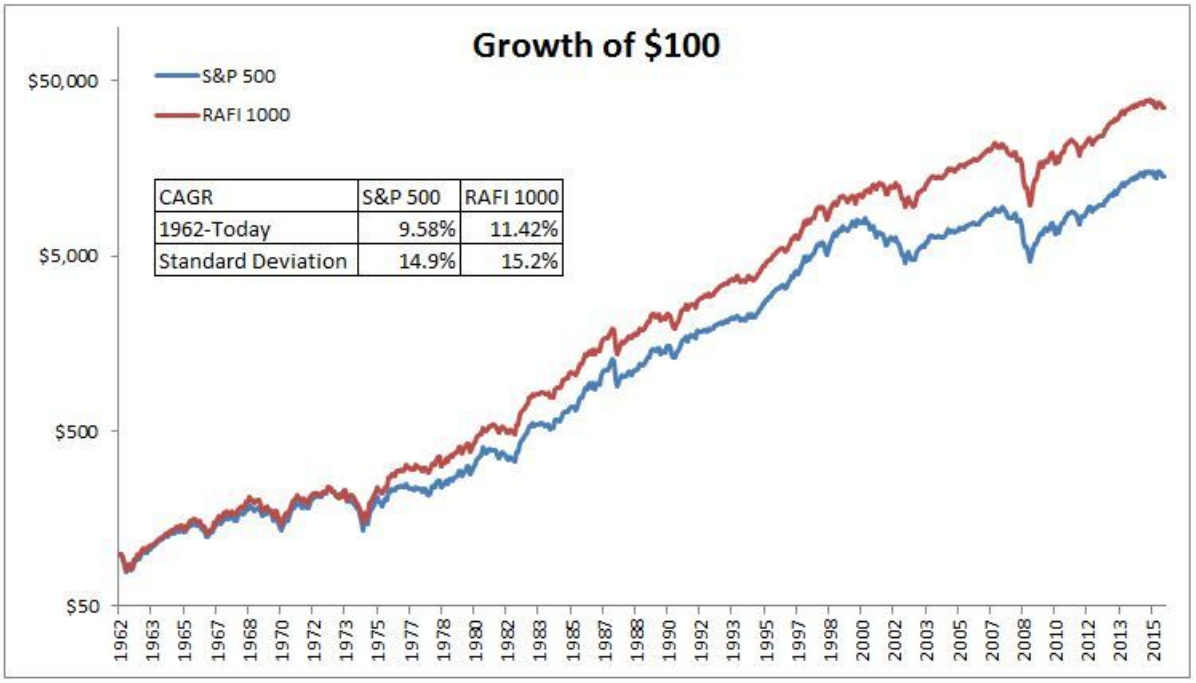


Fig: FTSE RAFI US 1000 (Fundamentally Weighted Index) vs S&P 500 (Market Cap Weighted Index)

The argument for fundamentally weighted indices is that the price of a stock is not always the best estimate of the company's true underlying value. Prices can be influenced by speculators, momentum traders, hedge funds, and institutions that buy and sell stocks for reasons that may not be related to the underlying fundamentals, such as for tax purposes. These influences can impact a stock's price for days or years, making it difficult to create an investment strategy that can consistently produce superior returns.

The theory is that if a stock's price falls for reasons not related to its fundamentals, then it is likely, although not certain, that overweighting this stock will generate higher-than-average returns. Similarly, stocks with prices that rise more than their fundamentals would indicate overpriced stocks that are likely to underperform the market.

Like capitalization-weighted indices, fundamental indices do not require that an investor analyze the underlying securities. However, they must be rebalanced periodically by purchasing more shares of firms with prices that have fallen more than a fundamental metric, such as dividends paid, and selling shares in firms with prices that have risen more than the fundamental metric.

	Traditional Market Cap Weighting	Fundamentally Weighting	Equal Weighting
Screens stocks by dividends, earnings, and valuation metrics?	No	Yes	Varies. Some equal weight indexes screen securities, others don't
Companies with the largest market size have the greatest impact on the performance and volatility of the index?	**Yes**	No	No
Equally weights stocks within an index?	No	No	Yes
Popular stock indexes that follow these strategies?	DJ Wilshire 5000, S&P 500, Russell 2000	FTSE RAFI U.S. 1000, WisdomTree Dividend Index	S&P Equal Weight Index, S&P Equal Weight Health Care

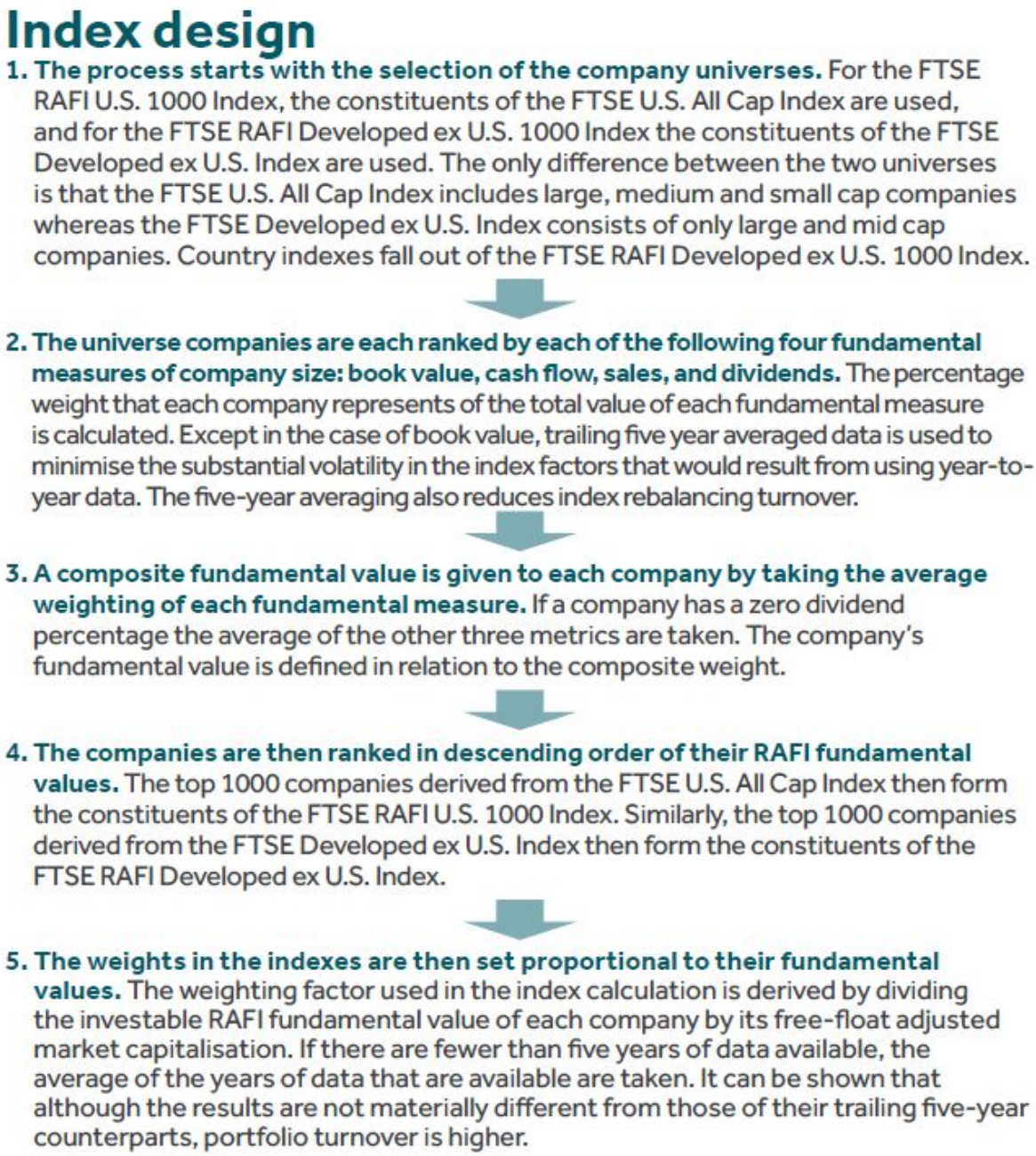
KEY TAKEAWAYS

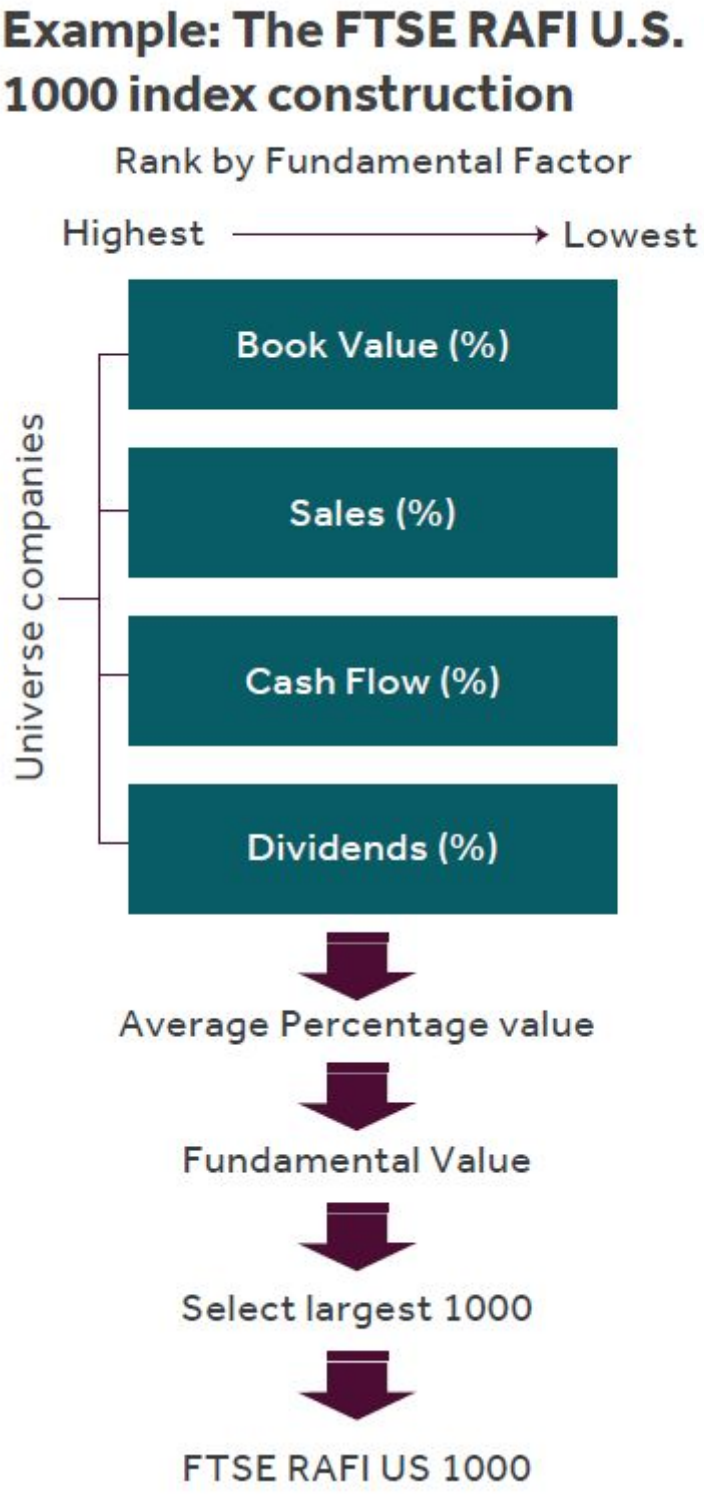
1. Stocks with the largest market size within a market-cap-weighted index will typically have the greatest impact on performance and volatility whereas mid and small-cap companies have less influence.
2. Equal weighted indexes offer an interesting alternative for investors not entirely convinced by either traditional or fundamental indexing. In an equal-weighted index, securities are assigned the same weighting or representation, regardless of their market size, financial metrics, or other factors.
3. Fundamental indexes attempt to outperform classic benchmarks by screening securities based upon various financial measures.
4. Some of these metrics include sales, book value, cash flow, valuation, and even dividends. Many of these indexes tend to have a value bias or tilt, which probably explains their strong performance when value stocks are in favor.

METHODOLOGY

The methodology used for the project was obtained from Research Affiliates, who were the first to create fundamentally weighted indexes. They have dozens of Indexes for each and every type of market and sector but all of them have the same design.

The infographics presented below will summarise the methodology and then the detailed explanation is written below.





COMPLETE EXPLANATION

Steps involved in designing the index:

1. Selection of the company universe:

Choose the companies based on the market cap of the company in India.

NOTE: Usually the universe is **all** the companies that fulfill certain criteria such as country of origin or market cap.

2. Ranking the companies in the universe by their fundamental value:

NOTE: All 4 measures need to be represented as a percentage ratio of each company in the universe by calculating the percentage ratio as [Sales of company A/Sum of Sales of N companies] x N

(where N is the total no. of companies in the universe)

The four fundamental measures used are:

A. **Sales** = Company sales averaged over the prior five years.

Profit & Loss

Consolidated Figures in Rs. Crores / View Standalone

PRODUCT SEGMENTS

	Mar 2009	Mar 2010	Mar 2011	Mar 2012	Mar 2013	Mar 2014	Mar 2015	Mar 2016	Mar 2017	Mar 2018	Mar 2019	Mar 2020	TTM
Sales -	151,101	203,174	265,050	357,677	395,957	433,521	374,372	272,583	303,954	390,823	568,337	595,887	489,160

B. **Cash Flow** = **Operating** cash flow averaged over the prior five years, not Financial or Investing cash flow.

ws

gures in Rs. Crores / View Standalone

	Mar 2009	Mar 2010	Mar 2011	Mar 2012	Mar 2013	Mar 2014	Mar 2015	Mar 2016	Mar 2017	Mar 2018	Mar 2019	Mar 2020
ng Activity +	16,287	20,494	33,338	24,483	36,918	43,261	34,374	38,134	49,550	71,459	42,346	98,074
g Activity +	-23,056	-18,212	-32,040	-6,301	-27,601	-73,070	-64,706	-36,186	-66,201	-68,192	-94,507	-75,694
ng Activity +	25,037	-11,134	14,950	-7,590	408	13,713	8,444	-3,210	8,617	-2,001	55,906	-2,541
	18,268	-8,851	16,248	10,592	9,725	-16,096	-21,888	-1,262	-8,034	1,266	3,745	19,839

C. **Book Value** = Company book value at the review date. (not past five years or an average of the same)

(Market cap ÷ current price) = total number of outstanding shares

No. Of shares x book value per share = company's book value

D. **Dividends** = total dividend distributions averaged over the last five years

Net Profit	14,969	24,503	19,294	19,724	20,879	22,493	23,566	29,745	29,901	36,075	39,588	39,354	40,788
EPS in Rs	22.29	35.12	27.63	28.27	30.31	32.62	34.14	43.03	43.11	53.39	58.55	58.20	62.56
Dividend Payout %	12%	9%	12%	13%	13%	12%	12%	10%	11%	10%	10%	10%	

3. Taking an Average of all the four fundamental measures:

The average values of all four fundamental measures are calculated. If the dividend percentage is 0 in any case, then the average of the other three fundamental measures is calculated.

This is done for all the companies in the universe.

4. Fundamental value calculation and selection of top companies:

The Fundamental Value is defined as 10,000,000 times the average of the four percentage representation figures above. However, for a stock with a zero dividend percentage, its Fundamental Value is defined as 10,000,000 times the average of the three remaining percentage representation figures (sales, cash flow, and book value).

5. The Fundamental value is adjusted by investable market capitalization:

Adjustment Factor, C_i for each stock is calculated by dividing its investable Fundamental Value by its investable market capitalization.

C_i = (Fundamental Value × Investability Weighting Factor) / (Price × Shares × Investability Weighting Factor)

V / P x S

(This is the same as Fundamental Value / Total Market Cap)

Example:
For Company A with a Fundamental Value of 20000.
If Company A had a price of US$ 3 and 5,000 shares in issue, its market capitalization would be US$ 15,000. If it was assumed that its investability weight was 50%, its investable market capitalization (i.e. after the application of any investability weighting) would be US$ 7,500. The adjustment factor for Company A would be calculated applying the formula would be equal to C_i = (20,000 × 50%)/(US$7500) = 1.34

Thus, applying the formula, the investable Fundamental Value is captured as 3 × 5,000 ×50% ×1.34 = 10000
(This is basically the same as Fundamental Value * Investability Weighting Factor)

Then the companies are arranged in descending order of their investable fundamental value and the top N companies are selected to make the index.

6. Calculation of Divisor, D:

$D = [\Sigma(P_i * S_i)]/100$

Where,

P = Price of i-th share on Base Date

S = Number of Shares of i-th share on Base Date

7. Finally the capital index value of the index is calculated by the following:

Index Value = [Σ(P*S*F*C)]/D

(IWF x V)/D

Where,

1. P = Price of i-th share on Base Date
2. S = Number of Shares of i-th share on Base Date
3. F = Investability Weighting Factor (between 0 to 1)
4. C = Adjustment Factor
5. D = Divisor

FUND UNIVERSE

First, we selected all the publicly available large-cap stocks in India, then created a spreadsheet filled with it along with other data related to it.

The other data are -

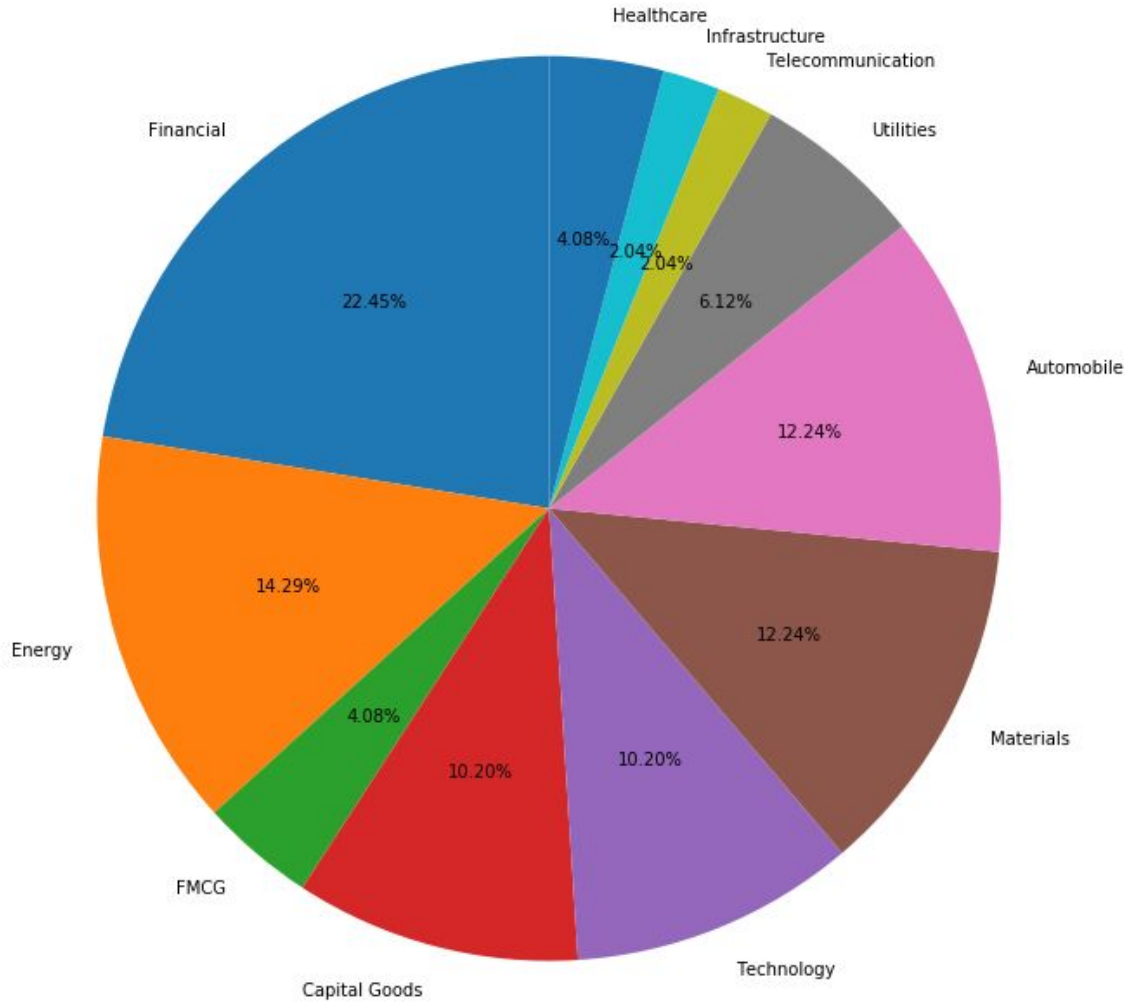
1. Stock Ticker
2. Total Shares
3. Market Cap
4. Book Value
5. Investability Weighting Factor (Free Float ratio)
6. Average Sales (past 5 years or 20 quarters)
7. Average Net Cash Flow (past 5 years or 20 quarters)
8. Average Dividends Paid (past 5 years or 20 quarters)

Then we calculate the RAFI Fundamental Value of each company which is the average of the 4 fundamental measures - Book Values Percentage, Average Sales Percentage, Average Net Cash Flow Percentage, and Average Dividends Paid.
The RAFI Adjustment Factor is the RAFI Fundamental Value divided by the market cap of each company.
Finally, the RAFI Fundamental Value is calculated by multiplying the RAFI Adjustment Factor with the Market Cap and Investability Weighting Factor.

Company Name	Company Ticker	Investibility weighting factor	Total Shares	Market Cap	Market Share Price	Book Value
3M INDIA LTD	3MINDIA	0.25	11334429.14	30942.99156	27300	2,104
ABB INDIA LIMITED	ABB	0.25	2001259299	6161.877383	30.79	3584
ABBOTT INDIA LTD	ABBOTINDIA	0.25	21249300	30981.4794	14580	2262
ACC LTD	ACC	0.455	137640998.5	601.9040866	43.73	11872
ADANI GREEN ENERGY LIMITED	ADANIGREEN	0.251	1554486186	187315.5854	1205	2155
ADANI PORTS AND SPECIAL ECONOMIC ZONE LT	ADANIPORTS	0.363	2046494859	146303.9175	714.9	27780
ADANI TRANSMISSION LIMITED	ADANITRANS	0.251	1104280999	85554.1704	774.75	8386
ALKEM LABORATORIES LIMITED	ALKEM	0.376	121000882.4	32469.98177	2683.45	6997
AMBUJA CEMENTS LTD	AMBUJACEM	0.367	1989155552	56362.72257	283.35	24781
APOLLO HOSPITALS ENTERPRISES LTD	APOLLOHOSP	0.692	143694600	43129.93419	3001.5	3136
ASIAN PAINTS LTD	ASIANPAINT	0.472	958165214.8	225925.776	2357.9	11030
AU SMALL FINANCE BANK LIMITED	AUBANK	0.71	306124962.6	36454.89117	1190.85	4325
AUROBINDO PHARMA LTD	AUROPHARMA	0.481	585167352.4	48908.28731	835.8	18342
AVENUE SUPERMARTS LIMITED	DMART	0.25	647774689.8	201778.577	3114.95	11320
AXIS BANK LTD	AXISBANK	0.861	3060611473	228199.1914	745.6	86340
BAJAJ AUTO LIMITED	BAJAJ-AUTO	0.463	288600861.8	106007.4255	3673.15	23719
BAJAJ FINANCE LIMITED	BAJFINANCE	0.437	603304035.7	326999.8369	5420.15	34284
BAJAJ FINSERV LIMITED	BAJAJFINSV	0.25	158908683.8	153584.4483	9664.95	1781
BAJAJ HOLDINGS & INVESTMENT LIMITED	BAJAJHLDNG	0.5	111293503.1	39115.2146	3514.6	31658
BANDHAN BANK LIMITED	BANDHANBNK	0.6	1606747370	54709.74793	340.5	15195
BANK OF BARODA	BANKBARODA	0.284	5171362100	40802.04697	78.9	76104
BERGER PAINTS INDIA LTD	BERGEPAINT	0.25	971701916.9	69709.89552	717.4	2867
BHARAT PETROLEUM CORPN. LTD	BPCL	0.459	2130276030	97992.69736	460	40060
BHARTI AIRTEL LTD	BHARTIARTL	0.437	5456361451	285094.8858	522.5	59340
BIOCON LTD	BIOCON	0.387	1189773621	46996.05801	395	7055
BOSCH LTD	BOSCHLTD	0.295	29379887.11	44069.83067	15000	8826
BRITANNIA INDUSTRIES LTD	BRITANNIA	0.494	240613116	83058.44459	3451.95	2674
CADILA HEALTHCARE LTD	CADILAHC	0.251	1021072047	45024.17191	440.95	11754
CIPLA LTD	CIPLA	0.633	808167230.7	64924.11447	803.35	17076

Average Dividends	Book Value percentage	Sales percentage	Cash flow percentage	Dividend percentage	RAFI Fundamental Value	Rafi adjustment factor Ci	Investible Rafi fundamental Value
0	0.05%	0.00049649060	0.00119455922	0	7313.387847	0.2363503811	1828.346962
95.91	0.09%	0.00141144933	0.00277230964	0.000655952998	14241.1906	2.309551876	3560.29765
189.862	0.05%	0.00065188709	0.00020595848	0.001298514734	6742.742843	0.2176378589	1685.685711
333.0425	0.28%	0.00268893109	0.00842532812	0.00227776276	40575.13404	67.41129515	18461.68599
0	0.05%	0.00012945777	0.00043142883	0	3586.816021	0.01914851887	900.2908214
317.87	0.66%	0.00195204558	0.0146382285	0.002173994156	63512.86877	0.4341159817	23055.17136
0	0.20%	0.00109001558	0.00266662041	0	19204.43506	0.224471057	4820.3132
195.818	0.17%	0.00112774462	0.00011273517	0.00133924934	10630.94923	0.3274085369	3997.236909
340.775	0.59%	0.00475778933	0.00674785044	0.002330647303	49400.61954	0.8764768146	18130.02737
80.022	0.07%	0.00167080702	0.00018427864	0.0005472909061	7880.113263	0.1827063595	5453.038378
943.36	0.26%	0.00336452657	-0.0002623260	0.006451880097	30477.07499	0.1348986182	14385.1794
0	0.10%	0.00044528129	0.00722589093	0	29016.91472	0.7959676681	20602.00945
147.402	0.44%	0.00345094965	0.00508392266	0.001008119944	34819.23441	0.7119291295	16748.05175
0	0.27%	0.00315941421	0.00014742291	0	20043.03921	0.09933184933	5010.759802
521.37	2.06%	0.00994152381	0.1329147679	0.003565782656	417654.6744	1.830219782	359600.6747
2024.246	0.57%	0.00510190962	-0.0006417232	0.01384433565	59936.52236	0.5653992826	27750.60985
298.618	0.82%	0.00294274732	0.00248884572	0.002042324808	39173.98696	0.119798185	17119.0323
0	0.04%	0.00049649060	0.00119455922	0	7056.007957	0.04594220335	1764.001989
399.852	0.76%	0.00010210421	0.00020379050	0.002734690002	26521.27427	0.6780296246	13260.63713
118.125	0.36%	0.00128902645	0.01403769691	0.0008078870596	49417.53403	0.9032674413	29650.52042
54.45	1.82%	0.00896571718	-0.0447168396	0.0003723974636	-42964.67809	-1.053003006	-12201.96858
170.834	0.07%	0.00103633030	0.00001083992	0.001168377379	7252.278021	0.1040351297	1813.069505
3484.638	0.96%	0.04746623892	-0.0018362825	0.02383232971	197596.8261	2.016444403	90696.9432
1012.576	1.42%	0.01740872994	0.02582285836	0.006925266008	160855.5785	0.5642176922	70293.88782
56.614	0.17%	0.00091343581	0.00079565015	0.0003871976126	9456.997949	0.2012295999	3659.858206
336.48	0.21%	0.00211255121	0.00027316599	0.002301272701	16992.16884	0.3855737265	5012.689807
401.348	0.06%	0.00196584026	0.00006937549	0.002744921529	13548.40937	0.1631189873	6692.914227
343.15	0.28%	0.00228445415	0.00095391299	0.002346890535	20987.7028	0.4661430053	5267.913404
564	0.41%	0.00301965955	0.00042492487	0.003856218481	28457.15977	0.4383141765	18013.38214

The sheet above was prepared in Google Sheets and the values of the Share Price and Market Cap were obtained using Google Finance API.
The fundamental measures data, IWF, etc were obtained from Screener.in
The sheet is available at - Index Fund Universe



The sectors of the 50 companies selected for our index based on their Fundamental Values.

FUND VALUE CALCULATION

After importing the CSV file, we sorted it based on the Fundamental Value of each company. We also added the Security Code for each company. Security Codes are 6 digit unique codes used to identify the company. The API we will be using to acquire the historical data for each stock requires the Security Code.

```
df = pd.read_csv("index_fund_universe_final.csv")
df = df.drop(columns="Total issued Share Capital")
df = df.drop(0)
df.sort_values(by=['Investible Rafi fundamental Value'], inplace=True, ascending=False)
df = df.reset_index(drop=True)
```

The security codes were obtained from [BSE official website] in CSV format. We added the security codes corresponding to each ticker in the original dataframe.

```
for i in range(1, len(df)) :
    ticker = df.loc[i, "Company Ticker"]
    row_num = sec_code[sec_code['Security Id']==ticker].index.values
    code = sec_code.at[row_num[0], "Security Code"]
    df.loc[i, 'Security Code'] = code
```

Final dataframe -

```
index_stocks
```

	Company Name	Company Ticker	Security Code	Investibility weighting factor	Total Shares	Market Cap	Market Share Price	Book Value	Sales (Rs Cr)	Unnamed: 8	...	Unnamed: 23	Averag Dividen
0	Total	NaN	0	52.5519	8.240710e+11	NaN	340424.03	41,83,181	3956034	4439456	...	152233.02	146214.74
1	AXIS BANK LTD	AXISBANK	532215	0.8610	3.064713e+09	2.274017e+05	742.00	86340	41,409	45,175	...	0	521.37
2	RELIANCE INDUSTRIES LTD	RELIANCE	500325	0.4926	6.585844e+09	1.449215e+06	2200.50	613422	2,72,583	3,03,954	...	3935.4	3553.06
3	HDFC BANK LTD	HDFCBANK	500180	0.7400	5.510632e+09	8.398755e+05	1524.10	176394	63162	73271	...	1362.7	2779.37
4	ICICI BANK LTD	ICICIBANK	532174	0.5254	6.913848e+09	4.185298e+05	605.35	122957	59294	60940	...	0	1188.41
5	KOTAK MAHINDRA BANK LTD	KOTAKBANK	500247	0.7397	1.981946e+09	3.765698e+05	1900.00	67135	20402	22324	...	0	94.13
6	STATE BANK OF INDIA	SBIN	500112	0.4216	8.917687e+09	3.473439e+05	389.50	251060	2,20,633	2,30,447	...	0	829.68
7	INDIAN OIL CORPORATION LTD	IOC	530965	0.4839	2.053500e+11	5.361679e+05	26.11	73837	346045	355379	...	3902.41	8937.09
8	ITC LTD	ITC	500875	0.8669	1.230491e+10	2.568034e+05	208.70	59083	39192	42768	...	12550.92	7699.43
9	OIL AND NATURAL GAS	ONGC	500312	0.2959	1.256989e+10	1.495816e+05	119.00	209994	1,24,036	2,82,506		6326.06	8112.45

The next step is to obtain the historical data for each stock. We will be using Alpha Vantage's API. The code required to do that is -

```
stocks = web.DataReader(ticker, "av-daily", start=start_date, end=date(2021, 3, 6), api_key=ALPHAVANTAGE_API_KEY)
```

where Ticker is the company's ticker.
The output received is a pandas dataframe. For eg -

	open	high	low	close	volume
2016-03-08	139.60	139.60	136.05	137.40	160215
2016-03-09	138.00	140.20	136.45	139.55	111308
2016-03-10	139.75	141.00	138.10	139.50	1380805
2016-03-11	137.10	140.25	137.10	138.10	56138
2016-03-14	138.70	138.80	137.65	138.45	51240
...	...	...	...	...	...
2021-03-01	218.50	228.85	217.65	227.55	940032
2021-03-02	228.70	229.50	223.45	224.85	442673
2021-03-03	228.60	230.00	223.70	227.45	378593
2021-03-04	225.00	229.90	224.20	225.10	1122167
2021-03-05	226.30	226.30	219.30	220.30	280269

Alpha Vantage's API doesn't have all the ticker values of the companies we want so we use the security code for the corresponding company to get the historical data.
We initialized a prices list with a length of 1232 and all values equal to 0. We will be using a try-except-finally block to get the data.

```
for i in range(1, 5):
    ticker = "BSE:"+df.loc[i, "Security Code"].astype(str)
    try:
        stocks = web.DataReader(ticker, "av-daily", start=start_date, end=date(2021, 3, 6), api_key=ALPHAVANTAGE_API_KEY)
        print(df.loc[i, "Company Ticker"], "code")
    except ValueError as ve:
        ticker = "BSE:"+df.loc[i, "Company Ticker"]
        stocks = web.DataReader(ticker, "av-daily", start=start_date, end=date(2021, 3, 6), api_key=ALPHAVANTAGE_API_KEY)
        print(df.loc[i, "Company Ticker"], "ticker")
    finally:
        for j in range(n):
            prices[j]+=stocks['close'][j]*df.loc[i, "Total Shares"]*df.loc[i, "Investible Rafi fundamental Value"]
```

The try block checks if we can get the data using the Security Code. If it succeeds, then we skip the except block. If we fail, a ValueError is raised and the except block catches it and gets the data using the Ticker. Finally, for every date, we add the price of the index which is calculated by multiplying the close price of the stock at a particular date by the total number of shares available and investable Rafi fundamental value.

The values obtained are then changed by dividing each value by the value of the index at the base date divided by 100. Basically changing the base value to 100 and then measuring the values so that the performance can be calculated and compared easily.

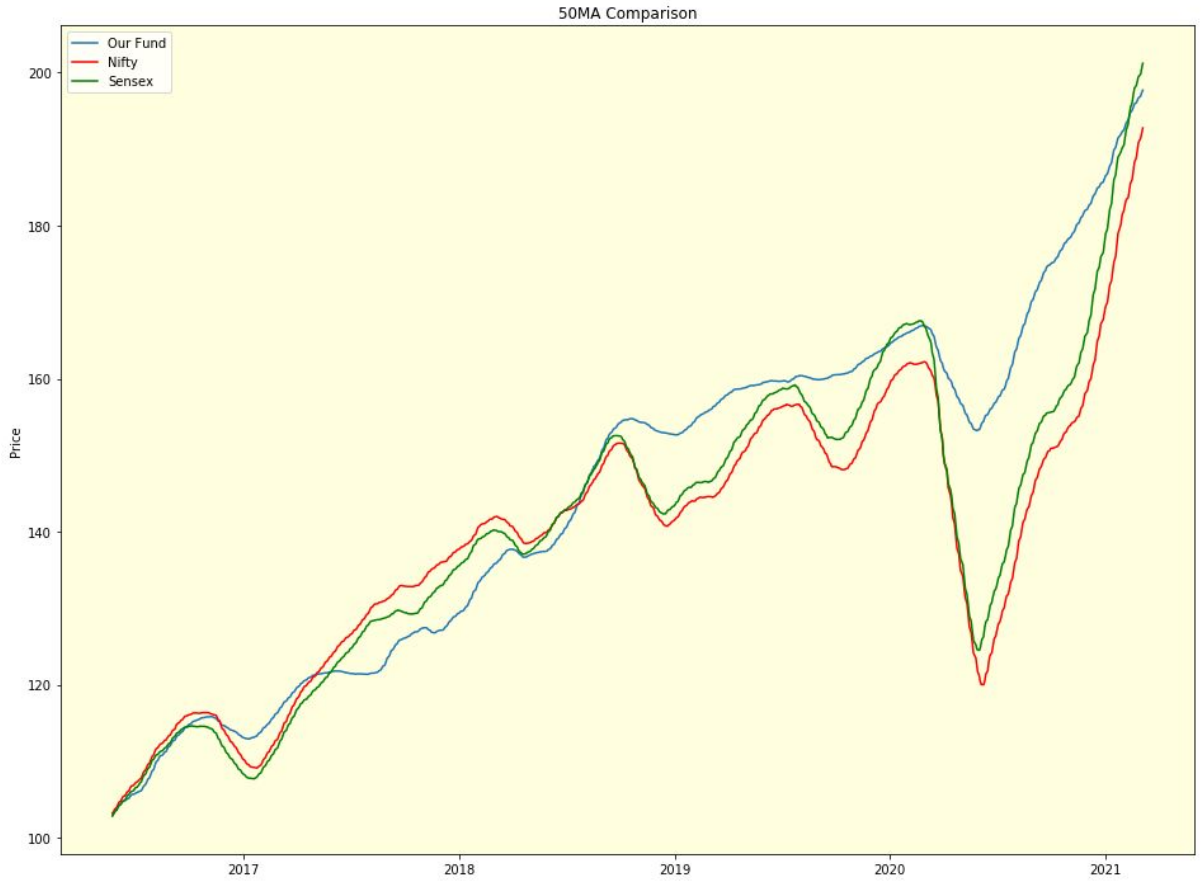
```
base = y_val[0]/100
for i in range(len(y_val)):
    y_val[i]/=base
y_val
```

The fund value is then plotted as a time-series graph.

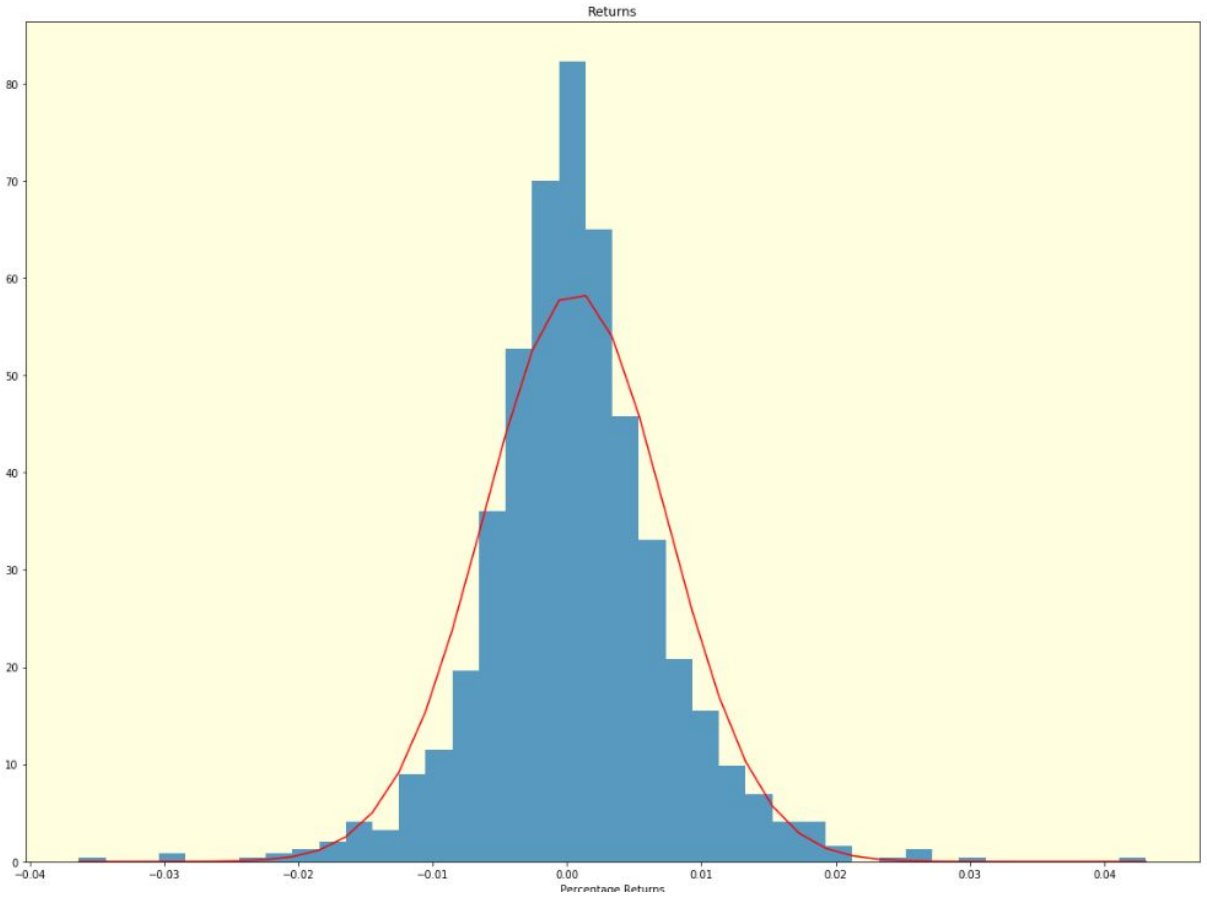
FUND PERFORMANCE

The time period we chose for backtesting is 6th March 2016 to 6th March 2021, a good five long year period. During this period, our fund had a CAGR of 15.01% whereas Sensex and Nifty had a CAGR of 15.40% and 15.06% respectively.

The 50 day moving average of the indexes can be used to visualise and compare the index funds' performance better. It is displayed below.



Calculating the returns and plotting a histogram of daily returns then fitting a probability distribution curve on it, we get -

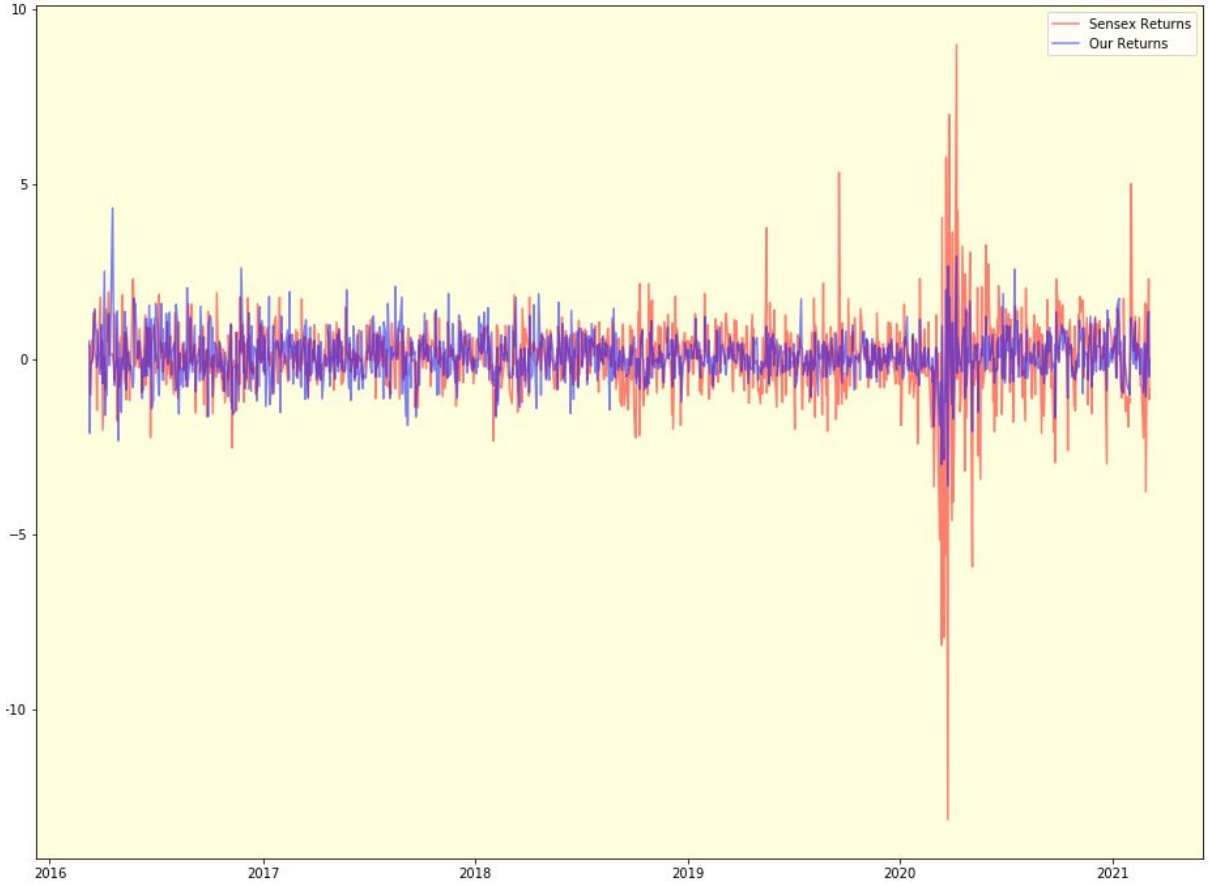


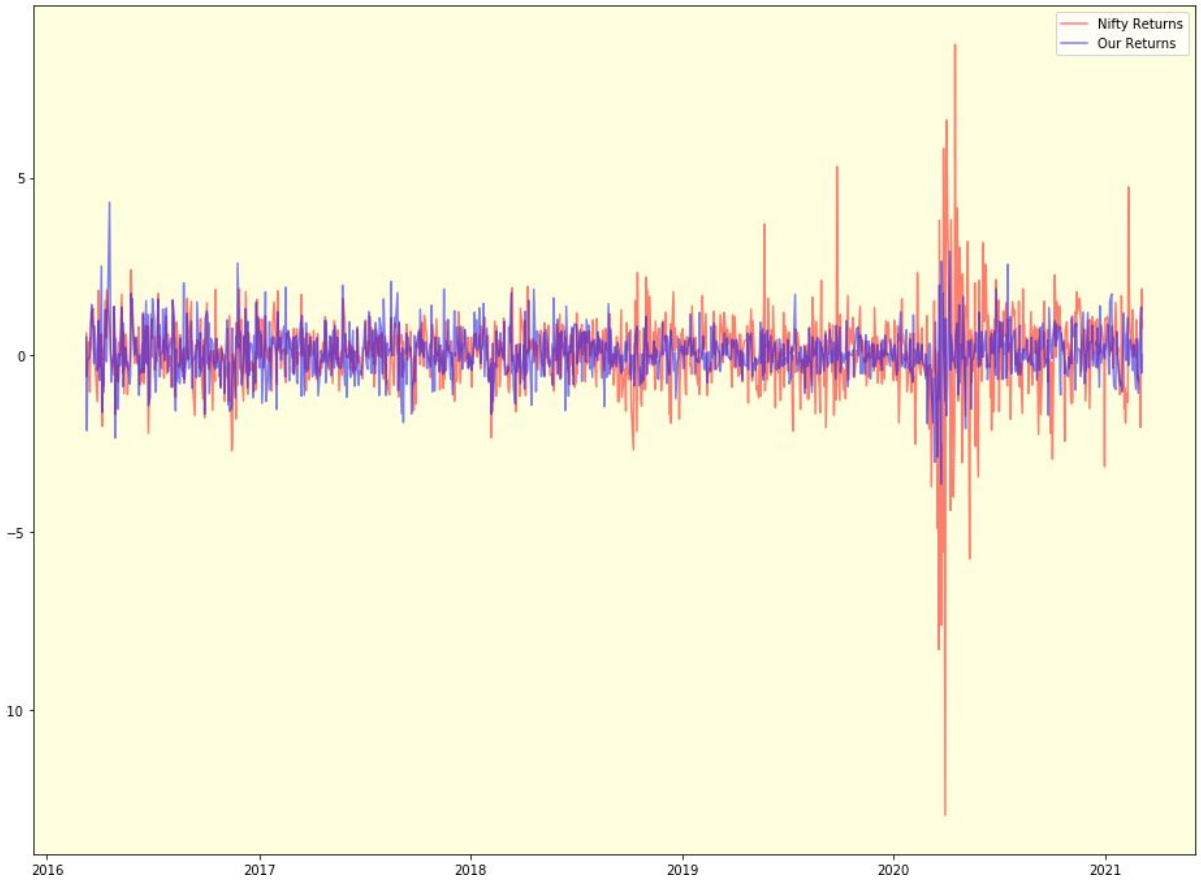
1. The curve is not Gaussian/Normal.
2. Skew value is 0.172, which makes it a right leaning curve i.e. we have more positive returns than negative returns.
3. The kurtosis value is 0.267 which means the tails are not very flattened and the curve is very close to being normal.
4. The skewness and kurtosis of Sensex and Nifty returns are shown below -

```
skew(sensex_returns)
-1.2979122012335027

skew(nifty_returns)
-1.3450344763361972

kurtosis(sensex_returns)-3
20.358208873767648

kurtosis(nifty_returns)-3
20.259624721251882
```

5. We can see that both Sensex and Nifty have very high kurtosis values which means they are flat tailed and have more extreme values compared to the returns of our fund.
6. This means that Sensex and Nifty tend to be more volatile compared to our fund.

Further proof for point 6 is shown below.


Sensex Returns
Our Returns
10
5
0
−5
-10
2016
2017
2018
2019
2020
2021


Nifty Returns
Our Returns
5
0
−5
10
2016
2017
2018
2019
2020
2021

The above figures are Returns of our Fund vs Returns of Sensex and Returns of our Fund vs Returns of Nifty respectively. We can see that both benchmark indexes are more volatile. To prove this with data, we obtained the volatility of all 3 indexes by calculating the standard deviation of the annualised daily returns.

```
np.std(returns)*(252**0.5)
```

```
0.10807322578872162
```

```
np.std(nifty_returns)*(252**0.5)
```

```
0.18104641115224968
```

```
np.std(sensex_returns)*(252**0.5)
```

```
0.18415436512781896
```

1. We can see that the volatility of Sensex and Nifty is more than our fund by almost 80%.
2. We also calculated the Sharpe Ratio of our fund and the benchmark indexes.
3. Sensex and Nifty have a Sharpe Ratio of ~0.56 over the last 5 years whereas our Fund has a Sharpe Ratio of 0.86 which is higher than the benchmark indexes Sharpe Ratio.

CONCLUSION

Although our Index Fund performed equally with respect to the CAGR of Sensex and Nifty, we believe that for a longer period, if backtested again, then our fund will outperform the benchmark indices by a good alpha value as fundamentally weighted indexes usually do.

Keeping that aside, we have seen that our fund is much less volatile than the benchmark indexes as its value does not completely depend on the stock price of few companies with the largest market cap, whereas the benchmark indices' values do. Even during the COVID-19 crash, the benchmark indices crashed ~35% whereas our fund crashed by ~15% proving the point mentioned above.

At the same time, since the fundamental measures are only sales, cash flow, dividends and book value, companies that have been poorly performing in other areas but performing well in these might be included in our fund (for eg Yes Bank). Due to this other fundamental measures need to be chosen too for the overall selection of the companies based on their fundamental value.

Further analysis and testing is required for making a Fund with better performance and also deciding on measures on which to rebalance it.

REFERENCES

1. Article on performance of smart beta funds
2. RAFI Fundamental Series Index Rulebook 1
3. RAFI Fundamental Series Index Rulebook 2