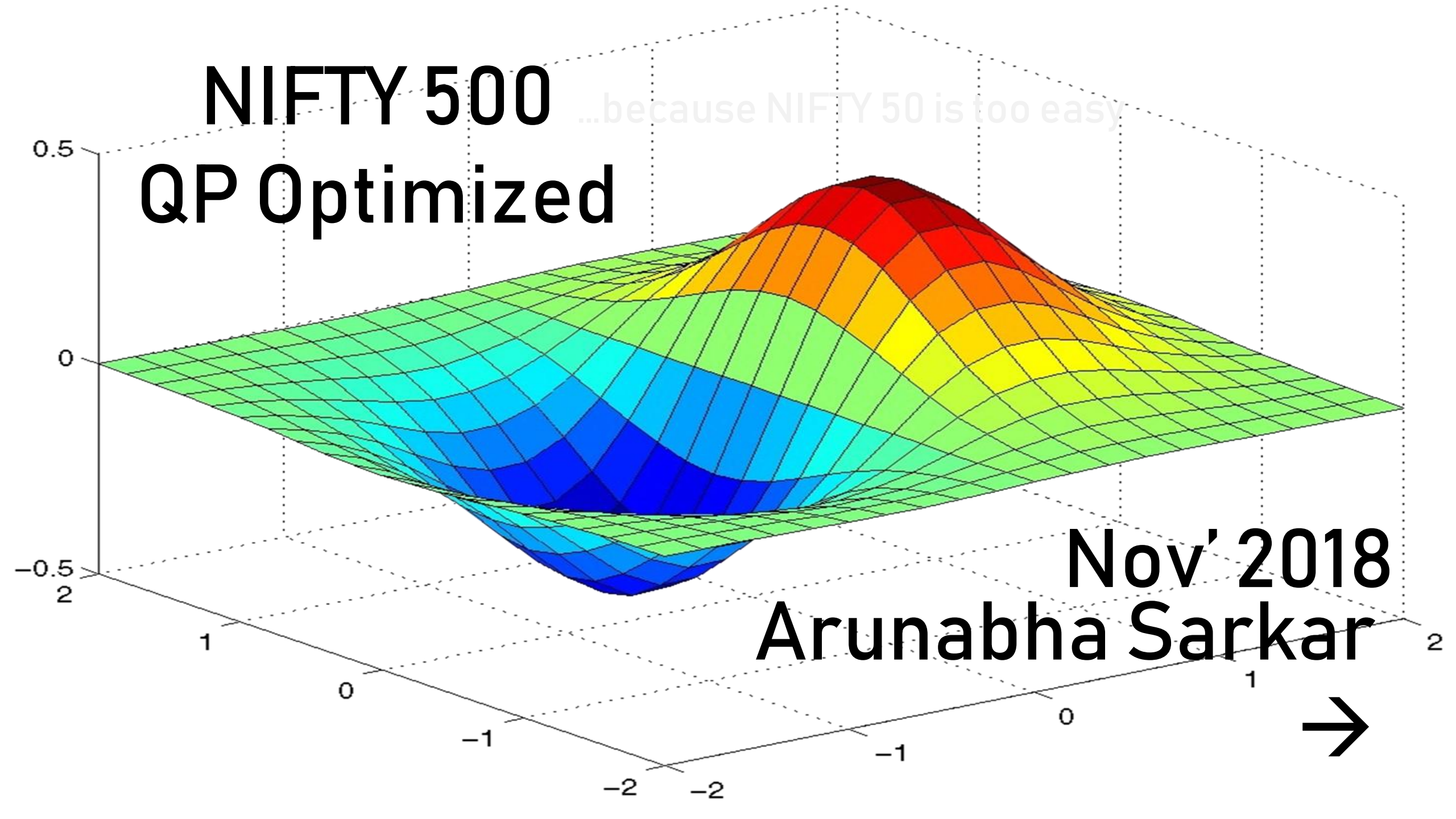
NIFTY 500
QP Optimized



Nov' 2018
Arunabha Sarkar

→

Overview & Salient Features

1. ~100% automated. 50 code lines. No manually entered tickers.
2. For tickers of NIFTY500, a file from NSE website is to be downloaded.
3. Data is automatically acquired by the code from Yahoo Finance.
4. Data processing is done automatically to remove NA (though with massive unnecessary data loss).
5. Subset of NA filtered data is automatically processed for QP for a range of required returns from 1% to 81% in steps of 1%.
6. Corresponding weights for each of the required returns is placed staggered in a single .csv file.
7. Efficient Frontier plot of portfolio ‘required returns’ vs ‘risk’.

Warning

This presentation is not investment advice.

Any investment carries the risk of partial or complete loss of principal.

Meant for educational purpose.

Past cannot be always extrapolated to the future.

“History doesn’t repeat itself; it rhymes” – Mark Twain

Warning

"I can calculate the motion of heavenly bodies, but not the madness of people."

– Sir Isaac Newton

The Goal

Optimize lowest risk weights of a portfolio of stocks from the NIFTY 500 index. Optimize using Quadratic Programming (QP).

Portfolio returns of a weighted portfolio:

$\sum_{i=1}^{n} \boldsymbol{w_i E(R_i)}$ ≡ a fixed user defined value (e.g. 20% per year).

1. i is the ith stock out total n stocks in the portfolio.
   w_i is the weight of the ith stock.
2. R_i is the return (/period) of the ith stock.
3. $\boldsymbol{E(R_i)}$ is the expected return (average over many time periods) of the ith stock.

The Goal

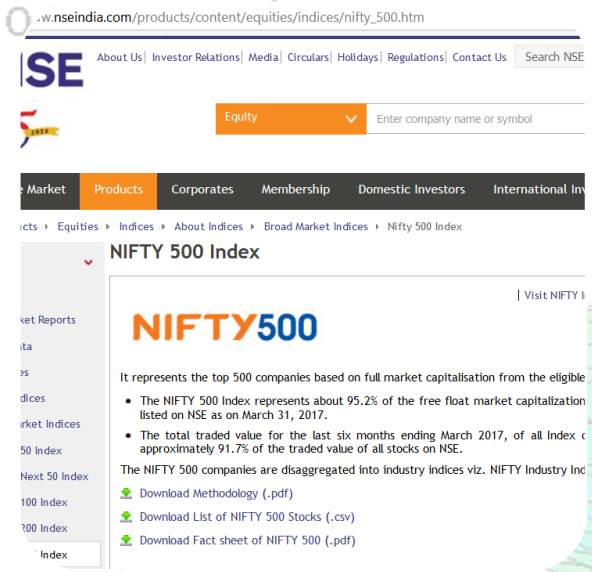
Optimize lowest risk weights of a portfolio of stocks from the NIFTY 500 index. Optimize using Quadratic Programming (QP).

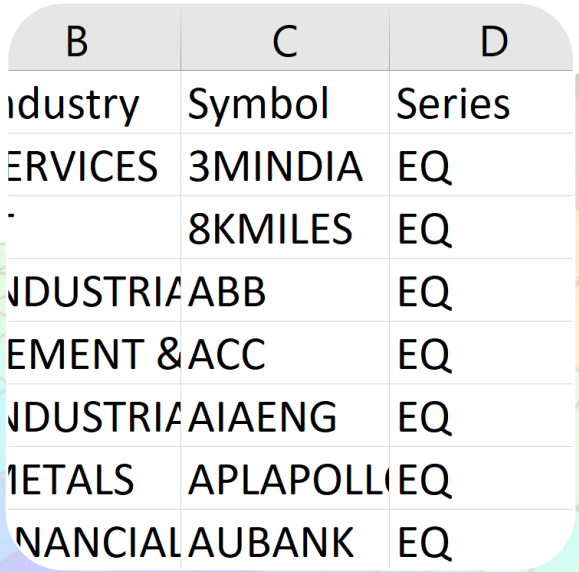
Portfolio risk (historical, by Standard Deviation):

$$\sum_{i=1}^{n} w_i^2 \, \sigma_i^2 + 2 \sum_{i=1}^{n} \sum_{\substack{j=1, \\ i \neq j}}^{n} w_i w_j \sigma_{ij}$$ **This is to be minimized**

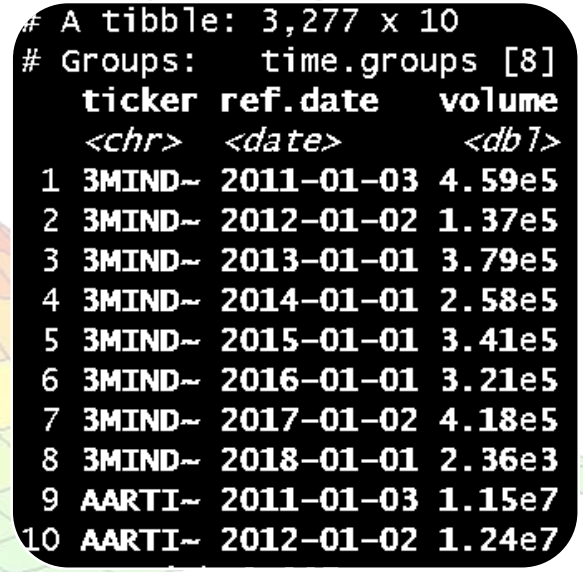
1. i is the ith stock out a total n
   w_i is the weight of the ith stock
2. σ_i^2 is the variance of returns of the ith stock
3. σ_{ij} is the covariance of returns of the ith & jth stock

Workflow





B	C	D
ıdustry	Symbol	Series
ERVICES	3MINDIA	EQ
	8KMILES	EQ
NDUSTRIA	ABB	EQ
EMENT &	ACC	EQ
NDUSTRIA	AIAENG	EQ
IETALS	APLAPOLL	EQ
NANCIAL	AUBANK	EQ



```
# A tibble: 3,277 x 10
# Groups:   time.groups [8]
   ticker ref.date   volume
   <chr>  <date>      <dbl>
 1 3MIND~ 2011-01-03 4.59e5
 2 3MIND~ 2012-01-02 1.37e5
 3 3MIND~ 2013-01-01 3.79e5
 4 3MIND~ 2014-01-01 2.58e5
 5 3MIND~ 2015-01-01 3.41e5
 6 3MIND~ 2016-01-01 3.21e5
 7 3MIND~ 2017-01-02 4.18e5
 8 3MIND~ 2018-01-01 2.36e3
 9 AARTI~ 2011-01-03 1.15e7
10 AARTI~ 2012-01-02 1.24e7
```

Read File

- From NSE documentation
- https://www.nseindia.com/products/content/equities/indices/nifty_500.htm

Get Symbols

- read.csv
- Only the tickers were obtained from this file

Get all monthly price data at once

- Package: BatchGetSymbols
- Source: Yahoo

Workflow

```
ll_Data_Wide$ret.adjusted.p
tibble: 10 x 411
ef.date    `3MINDIA.NS` AARTI
<date>           <dbl>
012-01-02        -
012-03-19
012-04-12
012-05-29
013-01-01        0.212
014-01-01        -
015-01-01        0.792
016-01-01        0.741
017-01-02        -
018-01-01        0.742
. with 401 more variables: A
AMBUJACEM.NS <dbl>, ANDHRABA
```

```
[1] "2016-01-01" "2017-01-
> (Full_Data_Wide_No_NA[[1
[1] 0.1002013 0.7416227 2.
> (Full_Data_Wide_No_NA[[2
[1] 0.546654515 0.00647220
> (Full_Data_Wide_No_NA[[3
[1] 0.1462106 0.4559527 0.
> (Full_Data_Wide_No_NA[[4
[1] 0.8164408 0.3709958 0.
> (Full_Data_Wide_No_NA[[4
```

	3MINDIA.NS	AAR
3MINDIA.NS	0.195048213	0.13
AARTIIND.NS	0.133059344	0.13
ABB.NS	0.045317144	-0.02
ACC.NS	0.039282312	-0.00
ADANIPORTS.NS	0.031940979	-0.04
ADANIPOWER.NS	0.046347390	-0.03
AEGISCHEM.NS	0.304106215	0.25
AIAENG.NS	-0.117655979	-0.11
AJANTPHARM.NS	-0.067021146	0.01
AKZOINDIA.NS	0.037201759	-0.00
ALBK.NS	0.002543873	-0.07
ALLCARGO.NS	0.077958431	0.06

Filter return/period

- By extracting the returns column

Exclude NA

- Package: tidyr
- Massive loss of data during automation

Calculate Covariances

- Converted to nearest positive definite matrix
- Package: Matrix

Workflow

$$\min \frac{1}{2} x^T Q x + c^T x,$$

$$Ax = b,$$

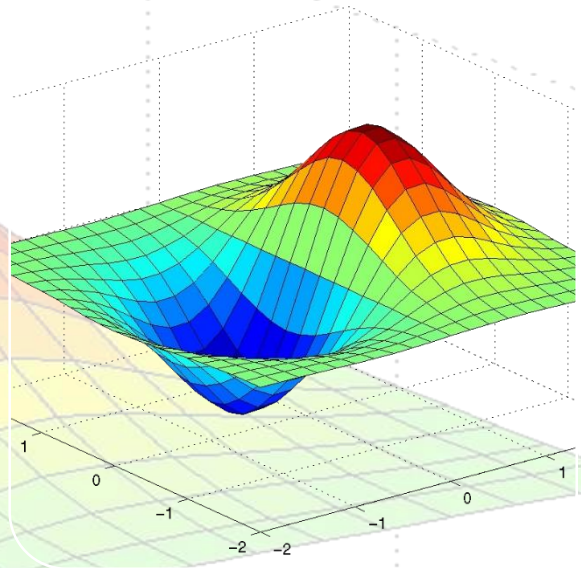
$$x^T Q_i x + d_i \le b_i,$$

$$x \ge 0,$$

```
equired_Return = seq 0.01,3.00,0.01)
or (i in seq_along(Required_Return))

 bvec_LS = c(1,Required_Return[i])
 Q = solve.QP(Covariance_Matrix,dvec_L
 if (sum(Q$solution) > 1){next}
 TEMP_DF = data.frame(Q$value, Require
 names(TEMP_DF) = c("Risk","Returns")
 Weights_DF = data.frame(Weight_Index,
 names(Weights_DF) = c("Name",paste0(R
 addDataFrame(Weights_DF, Long_And_Sho
 Starting_Column_Number = Starting_Col
 Efficient_Frontier = rbind(Efficient_
 All_Returns_Weights = append(All_Retu

aveWorkbook(Return_And_Weights_WorkBoo
ng(filename=paste0("Portfolio Efficien
lot(Efficient_Frontier, type = 'o', ma
v.off()
```



Initialize Amat, dvec, for QP; .csv & efficient frontier output.

Loop over range of required returns

- Collect all data

Analyze

- And discuss
- And improve

Results

	Name	1% Ret Wt			Name	2% Ret Wt			Name	3% Ret Wt			Name	4% Ret Wt
1	3MINDIA.NS	0.002283185		1	3MINDIA.NS	0.002283185		1	3MINDIA.NS	0.002283185		1	3MINDIA.NS	0.002283185
2	AARTIIND.NS	0.00266211		2	AARTIIND.NS	0.00266211		2	AARTIIND.NS	0.00266211		2	AARTIIND.NS	0.00266211
3	ABB.NS	0.002560999		3	ABB.NS	0.002560999		3	ABB.NS	0.002560999		3	ABB.NS	0.002560999
4	ACC.NS	0.002658044		4	ACC.NS	0.002658044		4	ACC.NS	0.002658044		4	ACC.NS	0.002658044
5	ADANIPORTS.NS	0.002548918		5	ADANIPORTS.NS	0.002548918		5	ADANIPORTS.NS	0.002548918		5	ADANIPORTS.NS	0.002548918
6	ADANIPOWER.NS	0.002503513		6	ADANIPOWER.NS	0.002503513		6	ADANIPOWER.NS	0.002503513		6	ADANIPOWER.NS	0.002503513
7	AEGISCHEM.NS	0.002120117		7	AEGISCHEM.NS	0.002120117		7	AEGISCHEM.NS	0.002120117		7	AEGISCHEM.NS	0.002120117
8	AIAENG.NS	0.003146327		8	AIAENG.NS	0.003146327		8	AIAENG.NS	0.003146327		8	AIAENG.NS	0.003146327
9	AJANTPHARM.NS	0.00336635		9	AJANTPHARM.NS	0.00336635		9	AJANTPHARM.NS	0.00336635		9	AJANTPHARM.NS	0.00336635
10	AKZOINDIA.NS	0.002661448		10	AKZOINDIA.NS	0.002661448		10	AKZOINDIA.NS	0.002661448		10	AKZOINDIA.NS	0.002661448
11	ALBK.NS	0.00262146		11	ALBK.NS	0.00262146		11	ALBK.NS	0.00262146		11	ALBK.NS	0.00262146
12	ALLCARGO.NS	0.00269176		12	ALLCARGO.NS	0.00269176		12	ALLCARGO.NS	0.00269176		12	ALLCARGO.NS	0.00269176
13	AMARAJABAT.NS	0.002991874		13	AMARAJABAT.NS	0.002991874		13	AMARAJABAT.NS	0.002991874		13	AMARAJABAT.NS	0.002991874
14	AMBUJACEM.NS	0.002737305		14	AMBUJACEM.NS	0.002737305		14	AMBUJACEM.NS	0.002737305		14	AMBUJACEM.NS	0.002737305
15	ANDHRABANK.NS	0.002504579		15	ANDHRABANK.NS	0.002504579		15	ANDHRABANK.NS	0.002504579		15	ANDHRABANK.NS	0.002504579
16	APLAPOLLO.NS	0.002152049		16	APLAPOLLO.NS	0.002152049		16	APLAPOLLO.NS	0.002152049		16	APLAPOLLO.NS	0.002152049
17	APLLTD.NS	0.002902778		17	APLLTD.NS	0.002902778		17	APLLTD.NS	0.002902778		17	APLLTD.NS	0.002902778
18	APOLLOHOSP.NS	0.002746486		18	APOLLOHOSP.NS	0.002746486		18	APOLLOHOSP.NS	0.002746486		18	APOLLOHOSP.NS	0.002746486
19	APOLLOTYRE.NS	0.002675063		19	APOLLOTYRE.NS	0.002675063		19	APOLLOTYRE.NS	0.002675063		19	APOLLOTYRE.NS	0.002675063
20	ASHOKA.NS	0.00229134		20	ASHOKA.NS	0.00229134		20	ASHOKA.NS	0.00229134		20	ASHOKA.NS	0.00229134
21	ASHOKLEY.NS	0.002447671		21	ASHOKLEY.NS	0.002447671		21	ASHOKLEY.NS	0.002447671		21	ASHOKLEY.NS	0.002447671
22	ASIANPAINT.NS	0.002715401		22	ASIANPAINT.NS	0.002715401		22	ASIANPAINT.NS	0.002715401		22	ASIANPAINT.NS	0.002715401
23	ASTRAL.NS	0.001945547		23	ASTRAL.NS	0.001945547		23	ASTRAL.NS	0.001945547		23	ASTRAL.NS	0.001945547
24	ATUL.NS	0.002809452		24	ATUL.NS	0.002809452		24	ATUL.NS	0.002809452		24	ATUL.NS	0.002809452
25	AUROPHARMA.NS	0.002708196		25	AUROPHARMA.NS	0.002708196		25	AUROPHARMA.NS	0.002708196		25	AUROPHARMA.NS	0.002708196
26	AVANTIFEED.NS	-0.000488275		26	AVANTIFEED.NS	-0.000488275		26	AVANTIFEED.NS	-0.000488275		26	AVANTIFEED.NS	-0.000488275
27	AXISBANK.NS	0.002685169		27	AXISBANK.NS	0.002685169		27	AXISBANK.NS	0.002685169		27	AXISBANK.NS	0.002685169
28	BAJAJCORP.NS	0.002544876		28	BAJAJCORP.NS	0.002544876		28	BAJAJCORP.NS	0.002544876		28	BAJAJCORP.NS	0.002544876

Results

Required Returns, till 81% →

	Name	1% Ret Wt
1	3MINDIA.NS	0.002283185
2	AARTIIND.NS	0.002662111
3	ABB.NS	0.000260999
4	ACC.NS	0.002658044
5	ADANIPORTS.NS	0.002548918
6	ADANIPOWER.NS	0.002503513
7	AEGISCHEM.NS	0.002120117
8	AMARAJABAT.NS	0.003146327
9	AJANTPHARM.NS	0.00336635
10	AKZOINDIA.NS	0.002661448
11	ALBK.NS	0.00262146
12	ALLCARGO.NS	0.00269176
13	AMARAJABAT.NS	0.003146327
14	AMBUJACEM.NS	0.002737305
15	ANDHRABANK.NS	0.002504579
16	APARINDS.NS	0.002152049
17	APLLTD.NS	0.002902778
18	APOLLOHOSP.NS	0.002746486
19	APOLLOTYRE.NS	0.002675063
20	ASHOKA.NS	0.00229134
21	ASHOKLEY.NS	0.002447671
22	ASIANPAINT.NS	0.002715401
23	ASTRAL.NS	0.001945547
24	ATUL.NS	0.002809452
25	AUROPHARMA.NS	0.002708196
26	AVANTIFEED.NS	-0.000488275
27	AXISBANK.NS	0.002685169
28	BAJAJCORP.NS	0.002544876

1 % required return (header)

Corresponding weights

	Name	2% Ret Wt
1	3MINDIA.NS	0.002283185
2	AARTIIND.NS	0.002662111
3	ABB.NS	0.000260999
4	ACC.NS	0.002658044
5	ADANIPORTS.NS	0.002548918
6	ADANIPOWER.NS	0.002503513
7	AEGISCHEM.NS	0.002120117
8	AMARAJABAT.NS	0.003146327
9	AJANTPHARM.NS	0.00336635
10	AKZOINDIA.NS	0.002661448
11	ALBK.NS	0.00262146
12	ALLCARGO.NS	0.00269176
13	AMARAJABAT.NS	0.003146327
14	AMBUJACEM.NS	0.002737305
15	ANDHRABANK.NS	0.002504579
16	APARINDS.NS	0.002152049
17	APLLTD.NS	0.002902778
18	APOLLOHOSP.NS	0.002746486
19	APOLLOTYRE.NS	0.002675063
20	ASHOKA.NS	0.00229134
21	ASHOKLEY.NS	0.002447671
22	ASIANPAINT.NS	0.002715401
23	ASTRAL.NS	0.001945547
24	ATUL.NS	0.002809452
25	AUROPHARMA.NS	0.002708196
26	AVANTIFEED.NS	-0.000488275
27	AXISBANK.NS	0.002685169
28	BAJAJCORP.NS	0.002544876

2 % required return (header)

Corresponding weights

	Name	3% Ret Wt
1	3MINDIA.NS	0.002283185
2	AARTIIND.NS	0.002662111
3	ABB.NS	0.000260999
4	ACC.NS	0.002658044
5	ADANIPORTS.NS	0.002548918
6	ADANIPOWER.NS	0.002503513
7	AEGISCHEM.NS	0.002120117
8	AMARAJABAT.NS	0.003146327
9	AJANTPHARM.NS	0.00336635
10	AKZOINDIA.NS	0.002661448
11	ALBK.NS	0.00262146
12	ALLCARGO.NS	0.00269176
13	AMARAJABAT.NS	0.003146327
14	AMBUJACEM.NS	0.002737305
15	ANDHRABANK.NS	0.002504579
16	APARINDS.NS	0.002152049
17	APLLTD.NS	0.002902778
18	APOLLOHOSP.NS	0.002746486
19	APOLLOTYRE.NS	0.002675063
20	ASHOKA.NS	0.00229134
21	ASHOKLEY.NS	0.002447671
22	ASIANPAINT.NS	0.002715401
23	ASTRAL.NS	0.001945547
24	ATUL.NS	0.002809452
25	AUROPHARMA.NS	0.002708196
26	AVANTIFEED.NS	-0.000488275
27	AXISBANK.NS	0.002685169
28	BAJAJCORP.NS	0.002544876

3 % required return (header)

Corresponding weights

	Name	4% Ret Wt
1	3MINDIA.NS	0.002283185
2	AARTIIND.NS	0.002662111
3	ABB.NS	0.000260999
4	ACC.NS	0.002658044
5	ADANIPORTS.NS	0.002548918
6	ADANIPOWER.NS	0.002503513
7	AEGISCHEM.NS	0.002120117
8	AMARAJABAT.NS	0.003146327
9	AJANTPHARM.NS	0.00336635
10	AKZOINDIA.NS	0.002661448
11	ALBK.NS	0.00262146
12	ALLCARGO.NS	0.00269176
13	AMARAJABAT.NS	0.003146327
14	AMBUJACEM.NS	0.002737305
15	ANDHRABANK.NS	0.002504579
16	APARINDS.NS	0.002152049
17	APLLTD.NS	0.002902778
18	APOLLOHOSP.NS	0.002746486
19	APOLLOTYRE.NS	0.002675063
20	ASHOKA.NS	0.00229134
21	ASHOKLEY.NS	0.002447671
22	ASIANPAINT.NS	0.002715401
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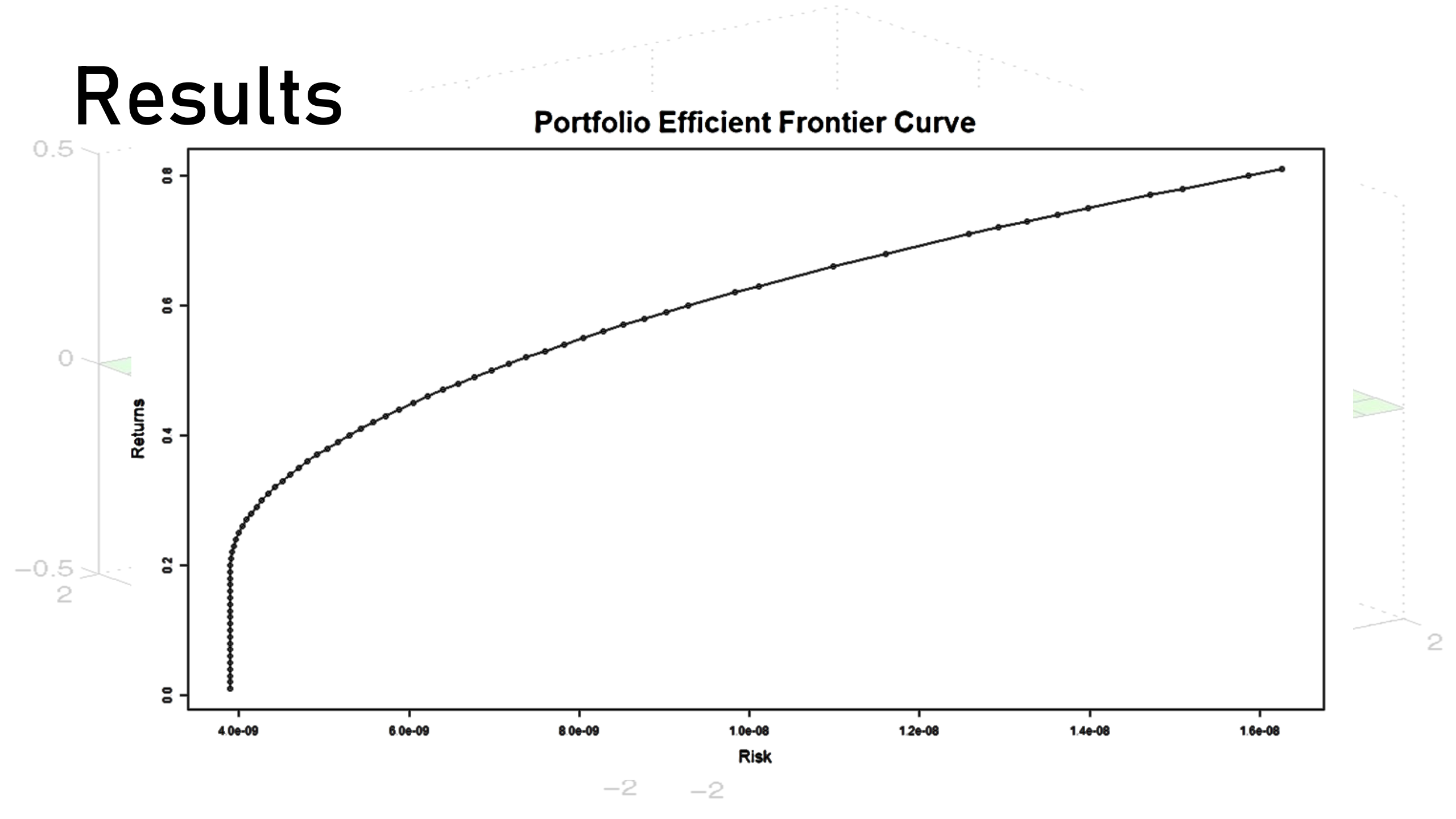
24	ATUL.NS	0.002809452
25	AUROPHARMA.NS	0.002708196
26	AVANTIFEED.NS	-0.000488275
27	AXISBANK.NS	0.002685169
28	BAJAJCORP.NS	0.002544876

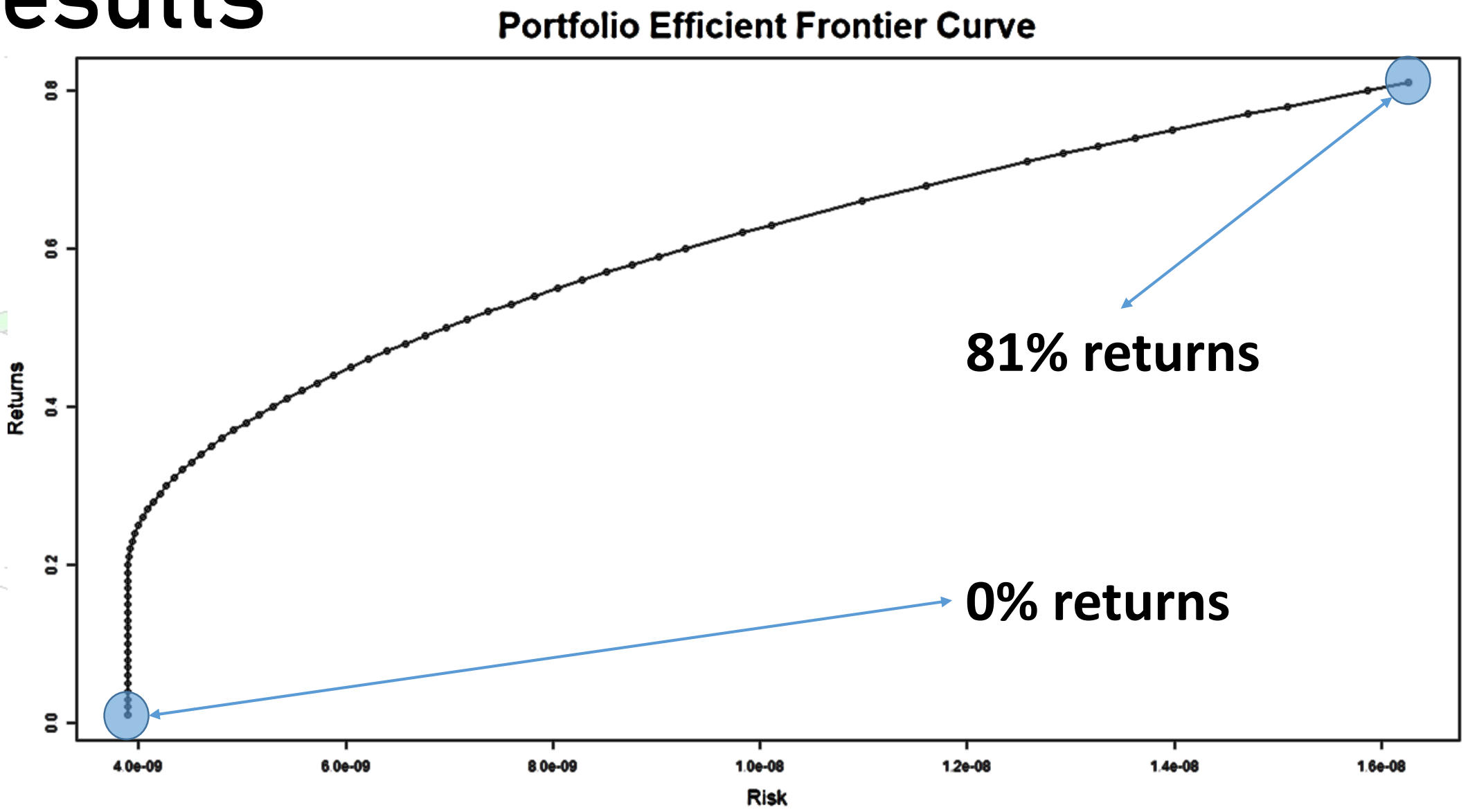
4 % required return (header)

Corresponding weights

Results


Portfolio Efficient Frontier Curve
Returns
0.0
0.2
0.4
0.6
0.8
4.0e-09
6.0e-09
8.0e-09
1.0e-08
1.2e-08
1.4e-08
1.6e-08
Risk

Results


Portfolio Efficient Frontier Curve
Returns
0.0
0.2
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0.6
0.8
4.0e-09
6.0e-09
8.0e-09
1.0e-08
1.2e-08
1.4e-08
1.6e-08
Risk
81% returns
0% returns

Analysis, Discussion & Future

Why doesn't the efficient frontier look like one?

Firstly, the completely automated data cleaning removed most of the data. Either the code was inefficient usage of Batchgetdata() tools, or, alternative ticker by ticker data has to be collected using getSymbols().

Secondly, Even with more manual and proper data handling using getSymbols(), pair-wise covariance has to be done using manual functions because the default requires data of same length… which is not realistic with broad index such as NIFTY500

Analysis, Discussion & Future

Why isn't the covariance matrix positive definite?

Not sure, but this is suggestive of vast majority of components of NIFTY500 have performed in opposite of the index heavy weights.

Analysis, Discussion & Future

How else to improve, besides getSymbols() & custom covariance?

Incorporate long only situations.

Add stuff from other markets like commodities, PMs, cryptos, hedging by FnO, tax on gains, portfolio rebalancing, etc.

Some weights obtained from QP may amount to fractional # of stocks, only integer solutions should be considered.

Analysis, Discussion & Future

Optimization for only integer # stocks?

This is called Mixed Integer Quadratic Programming (MIQP). Software-API + packages in R, others:

1. IBM's CPLEX. Software: https://www.ibm.com/products/ilog-cplex-optimization-studio, R package: https://cran.r-project.org/web/packages/cplexAPI/index.html

2. Gurobi Optimizer. Software: http://www.gurobi.com/downloads/download-center, R package: inside the software download. Guide: https://cran.r-project.org/web/packages/prioritizr/vignettes/gurobi_installation.html

3. In Python, using OSQP package: https://github.com/oxfordcontrol/miosqp

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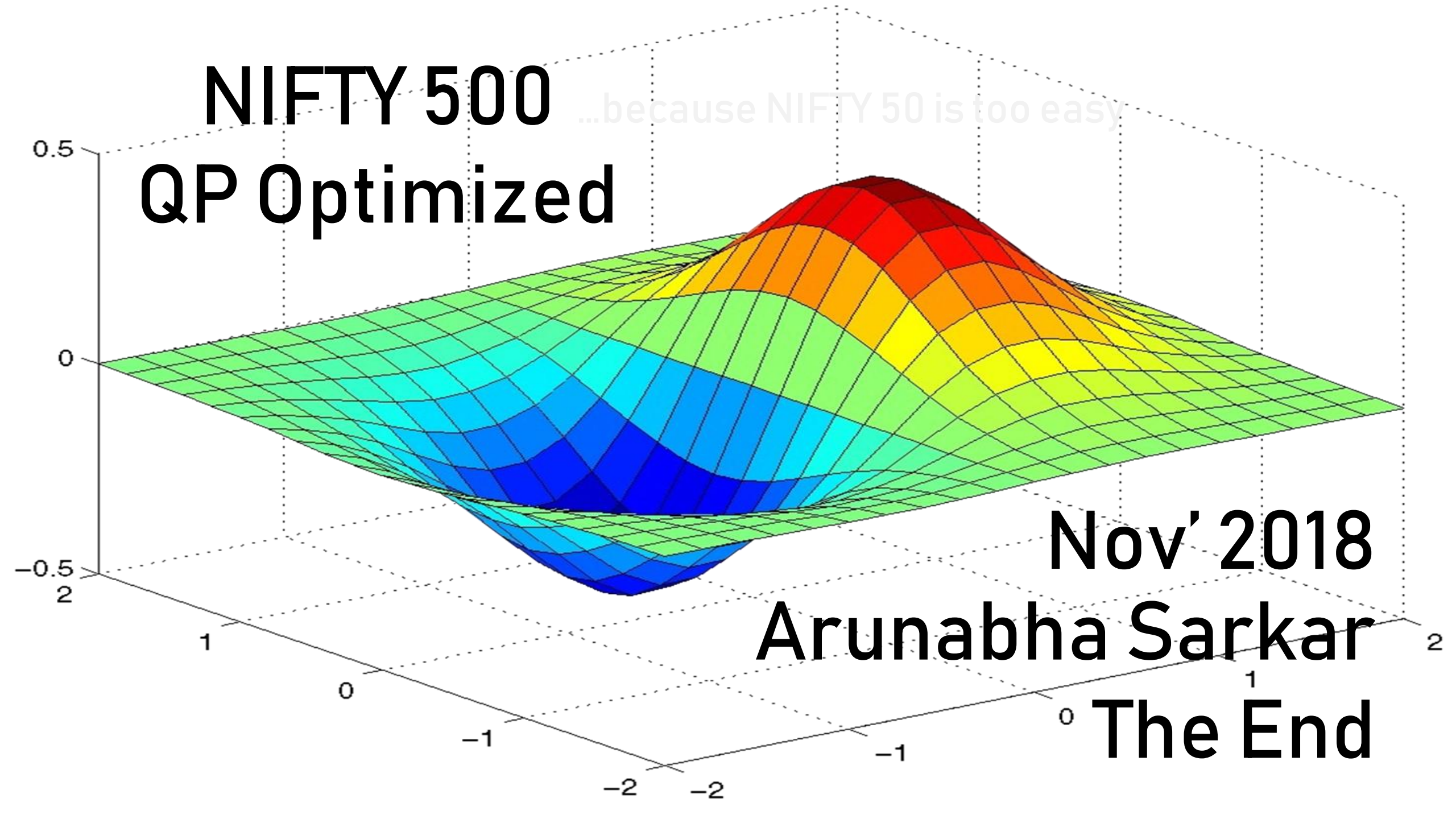

Nov' 2018

Arunabha Sarkar

The End