```
%Black-Litterman Portfolio implementation by K.Tomov

T = readtable('BLportfolio.xlsx'); %historical log-returns
assetNames = ["WNS","GPN","JD","LOGI","VIPS","BIDU"];
benchmarkName = "NYSE";
head(T(:,["Date" benchmarkName assetNames]))
```

Date	NYSE	WNS	GPN	JD	LOGI	VIPS	BIDU
14-May-2020	10927	40.68	159.82	45.736	49.579	16.29	96.02
15-May-2020	10947	40.14	165.22	47.502	49.899	16.436	99.86
18-May-2020	11402	42.77	175.17	51.874	51.433	16.212	107.59
19-May-2020	11249	43.25	174.99	50.687	52.346	15.51	109.75
20-May-2020	11420	43.04	175.53	50.734	53.899	14.827	108.52
21-May-2020	11352	41.73	171.58	49.109	52.186	14.729	110.03
22-May-2020	11332	41.95	171.91	46.614	53.156	14.612	103.32
26-May-2020	11603	48.22	172.58	49.137	53.146	15.588	108.36

```
retnsT = tick2ret(T(:, 2:end));
assetRetns = retnsT(:, assetNames);
benchRetn = retnsT(:, "NYSE");
numAssets = size(assetRetns, 2);

v = 5;  % total 5 views (BLACK LITTERMAN ASSUMPTIONS) <Portfolio weights optimized
on factors
P = zeros(v, numAssets);
q = zeros(v, 1);
Omega = zeros(v);

% View 1
P(1, assetNames=="JD") = 1; %<- needs reformulation
q(1) = 0.40;%<- needs reformulation
Omega(1, 1) = 1e-8;%<- needs reformulation

% View 2
P(2, assetNames=="LOGI") = 1; %<- needs reformulation
q(2) = 0.1;%<- needs reformulation
Omega(2, 2) = 1e-5;%<- needs reformulation

% View 3 (one will outperform the other) EI: VIPS will outperform GPN by X%
P(3, assetNames=="VIPS") = 1; %<- needs reformulation
P(3, assetNames=="GPN") = -1; %<- needs reformulation
q(3) = 0.25;%<- needs reformulation (mean returns estimates)
Omega(3, 3) = 1e-6;%<- needs reformulation (uncertainty function)

% View 4
P(4, assetNames=="BIDU") = 1; %<- needs reformulation
q(4) = 0.1;%<- needs reformulation
Omega(4, 4) = 1e-6;%<- needs reformulation

% View 5
P(5, assetNames=="WNS") = 1; %<- needs reformulation
```

```
q(5) = 0.10;%<- needs reformulation
Omega(5, 5) = 1e-7;%<- needs reformulation
%____________________________________________________________________________________________________________


viewTable = array2table([P q diag(Omega)], 'VariableNames', [assetNames
"View_Return" "View_Uncertainty"])
```

viewTable = 5×8 table

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	WNS	GPN	JD	LOGI	VIPS	BIDU	View_Return
1	0	0	1	0	0	0	0.4000
2	0	0	0	1	0	0	0.1000
3	0	-1	0	0	1	0	0.2500
4	0	0	0	0	0	1	0.1000
5	1	0	0	0	0	0	0.1000

```
bizyear2bizday = 1/252;
q = q*bizyear2bizday;
Omega = Omega*bizyear2bizday;

Sigma = cov(assetRetns.Variables);

tau = 1/size(assetRetns.Variables, 1);
C = tau*Sigma;

function [wtsMarket, PI] = findMarketPortfolioAndImpliedReturn(assetRetn, benchRetn)
% Find the market portfolio that tracks the benchmark and its corresponding implied
expected return.
Sigma = cov(assetRetn);
numAssets = size(assetRetn,2);
LB = zeros(1,numAssets);
Aeq = ones(1,numAssets);
Beq = 1;
opts = optimoptions('lsqlin','Algorithm','interior-point', 'Display',"off");
wtsMarket = lsqlin(assetRetn, benchRetn, [], [], Aeq, Beq, LB, [], [], opts);
shpr = mean(benchRetn)/std(benchRetn);
delta = shpr/sqrt(wtsMarket'*Sigma*wtsMarket);
PI = delta*Sigma*wtsMarket;
end

[wtsMarket, PI] = findMarketPortfolioAndImpliedReturn(assetRetns.Variables,
benchRetn.Variables);

mu_bl = (P'*(Omega\P) + inv(C)) \ ( C\PI + P'*(Omega\q));
cov_mu = inv(P'*(Omega\P) + inv(C));
```

```
mu_bl = (P'*(Omega\P) + inv(C)) \ ( C\PI + P'*(Omega\q));
cov_mu = inv(P'*(Omega\P) + inv(C));

table(assetNames', PI*252, mu_bl*252, 'VariableNames', ["Asset_Name", ...
    "Prior_Belief_of_Expected_Return", "Black_Litterman_Blended_Expected_Return"])
```

ans = 6×3 table

...

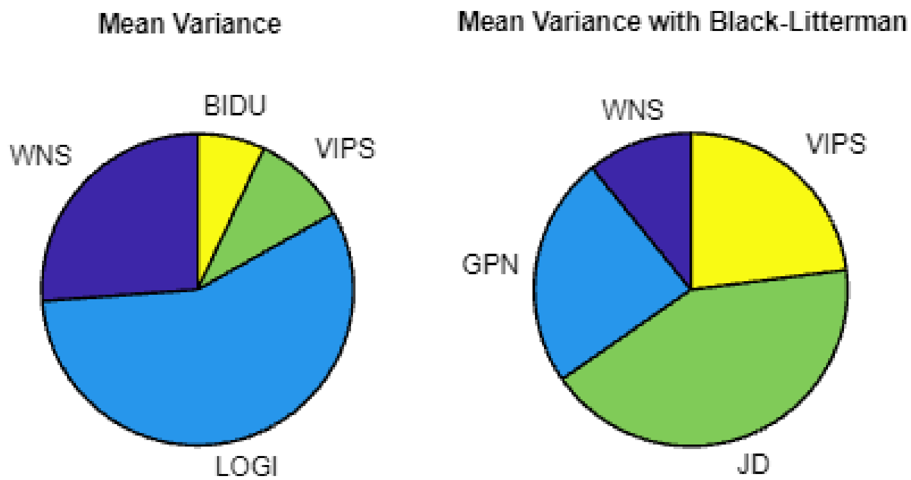
	Asset_Name	Prior_Belief_of_Expected_Return
1	"WNS"	0.2125
2	"GPN"	0.2371
3	"JD"	0.2333
4	"LOGI"	0.2030
5	"VIPS"	0.2199
6	"BIDU"	0.2426

```
port = Portfolio('NumAssets', numAssets, 'lb', 0, 'budget', 1, 'Name', 'Mean
Variance');
port = setAssetMoments(port, mean(assetRetns.Variables), Sigma);
wts = estimateMaxSharpeRatio(port);

portBL = Portfolio('NumAssets', numAssets, 'lb', 0, 'budget', 1, 'Name', 'Mean
Variance with Black-Litterman');
portBL = setAssetMoments(portBL, mu_bl, Sigma + cov_mu);
wtsBL = estimateMaxSharpeRatio(portBL);

ax1 = subplot(1,2,1);
idx = wts>0.001;
pie(ax1, wts(idx), assetNames(idx));
title(ax1, port.Name ,'Position', [-0.05, 1.6, 0]);

ax2 = subplot(1,2,2);
idx_BL = wtsBL>0.001;
pie(ax2, wtsBL(idx_BL), assetNames(idx_BL));
title(ax2, portBL.Name ,'Position', [-0.05, 1.6, 0]);
```




```
%weights distributed and compared with standard mean variance optimization in %
table(assetNames', wts, wtsBL, 'VariableNames', ["AssetName",
"Mean_Variance","Mean_Variance_with_Black_Litterman"])
```

ans = 6×3 table

	AssetName	Mean_Variance	Mean_Variance_with_Black_Litterman
1	"WNS"	0.2618	0.1085
2	"GPN"	2.8119e-15	0.2384
3	"JD"	3.0595e-14	0.4232
4	"LOGI"	0.5698	7.6978e-11
5	"VIPS"	0.0986	0.2299
6	"BIDU"	0.0698	8.4234e-16