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FIN285: mini-project

Objective

My mini project will be a comparison of risk versus return given a set of the following portfolios, varied by horizon time:

* Asian options
* Vanilla options
* Regular stock

Summary of Experiment

I utilized historical dow prices to generate sample returns for asian options, vanilla options, and regular stock. Black-Scholes was used to determine vanilla option prices and “progressive risk-neutral option pricing” (explained later) to generate Asian option prices.

The simulation has “sub-trials” (determined by the variable *tsize*), and “iterations”. (determined by the variable *iterations*) Each iteration has a randomly generated horizon and strike price. Within each iteration, there is a set of sub-trials, each with a randomly generated price path, starting from a price of 1. Each iteration captures the mean value of its sub-trials and the risk, as measured by an expected tail loss.

My hypothesis is that if Black-Scholes (and progressive risk-neutral option pricing) applies to both Asian and vanilla options, then according to the risk-return tradeoff concept, a higher return should be counter-balanced by a higher risk, both within iterations and across the three portfolios.

Notes

* When generating price paths, I used both historical price series and randomly generated series based on randomly drawn historical data.
* Dow and “risk-free” data sets are from Jan. 1, 1897 to June 15, 2003. Risk-free data is from 1897-1972 (yearly) and Jan. 15, 1973 to June 15, 2003 (monthly) using one-year interest rate of US government bonds.
* All graph data is based on initial conditions of the included code unless otherwise noted.

Preliminary Results

Initial comparisons of various methods in determining risk versus return (using only regular stock portfolios) show:
* Case 1: the 95% ETL (expected tail loss) rises as the cumulative return decreases (contrary to risk-return tradeoff), given a horizon of 40.
* Case 2: Lower ETLs (90%, 80%) do not need a smaller trial size per iteration for valid results and are therefore faster to compute, but have a greater distribution spread.
* Case 3: The standard deviation risk measure, compared to ETL, gives a much less significant result.
* Case 4: The comparison between historical sets of returns versus a randomly generated set (random draw from all the individual returns), the result is less significant than in case 1.
* Case 5: Compared to a single horizon data set, one with different horizons (distributed with a random-normal probability, and cut-offs at extremes) has the expected risk-return tradeoff, but only if the horizon is not compensated for when calculating returns and risks. Normally (as in the printed code), the horizon is compensated for by exponentiating each return by: (*expected mean*)/(*current iteration’s horizon*).

There is no discernible relationship between ETL (or std) and dow returns, even with 2000 iterations and 2000 trials per iteration. Nevertheless, the relationship between ETL and return is very strong, and since it mimics the basic law of risk-return tradeoff, I compared both with and without horizon adjustment.

Results 2

As mentioned earlier, I used the Black-Scholes function to generate prices for vanilla options. For Asian options, I used a "progressive risk-neutral option pricing", similar to the risk-neutral option pricing adopted in our asianopt.m example:

For each trial (each set of trials has the same strike price and the same horizon), I begin with a starting price (.1, or 10% of portfolio value). I then use the formula "exp(-risk free rate*(horizon/250))*mean(asianput)" to calculate the price. I adjust the mean value accordingly. I then remove the first half of the Asian option returns in the mean price and ETL calculations to compensate for inaccurate starting prices. The Asian prices should therefore line up with each other heavily, and they do.

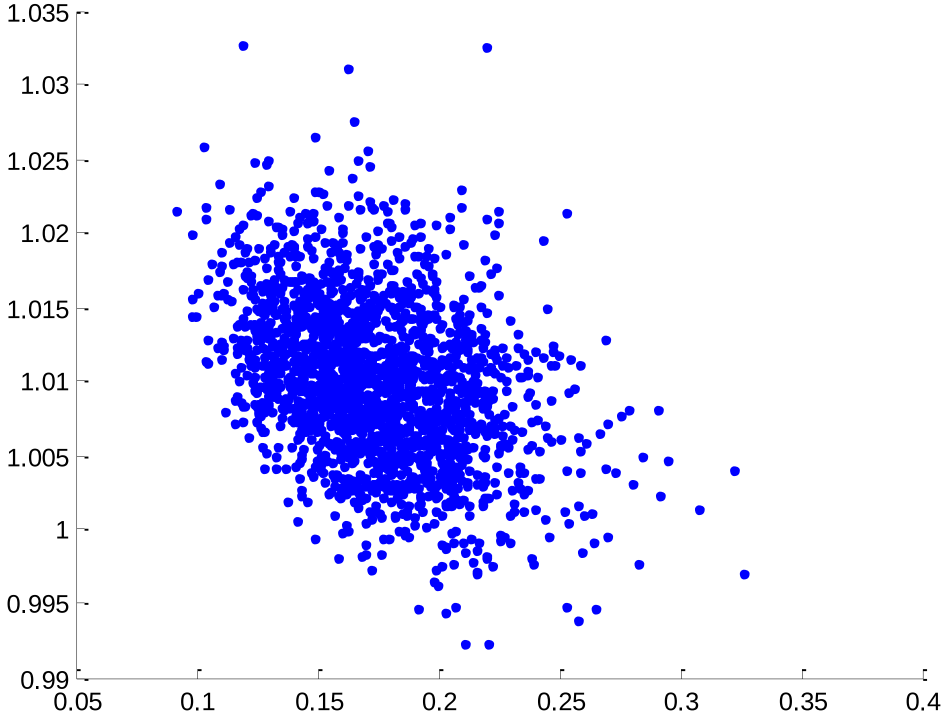
My results indicate a linear progression from Asian options (least return and smallest risk) to stocks (highest return and highest risks), in accordance with my hypothesis. The mean ratio between regular stock returns, vanilla option returns, and Asian option returns are exact ratios (100% to 49.40% and -65.53...%), in accordance with my hypothesis. There is a strong negative correlation between returns and ETL (the higher return, the lower the ETL), contrary to my hypothesis. However, it is possible that a higher ETL means a higher return within the same stock. (in this case, the dow)

Code

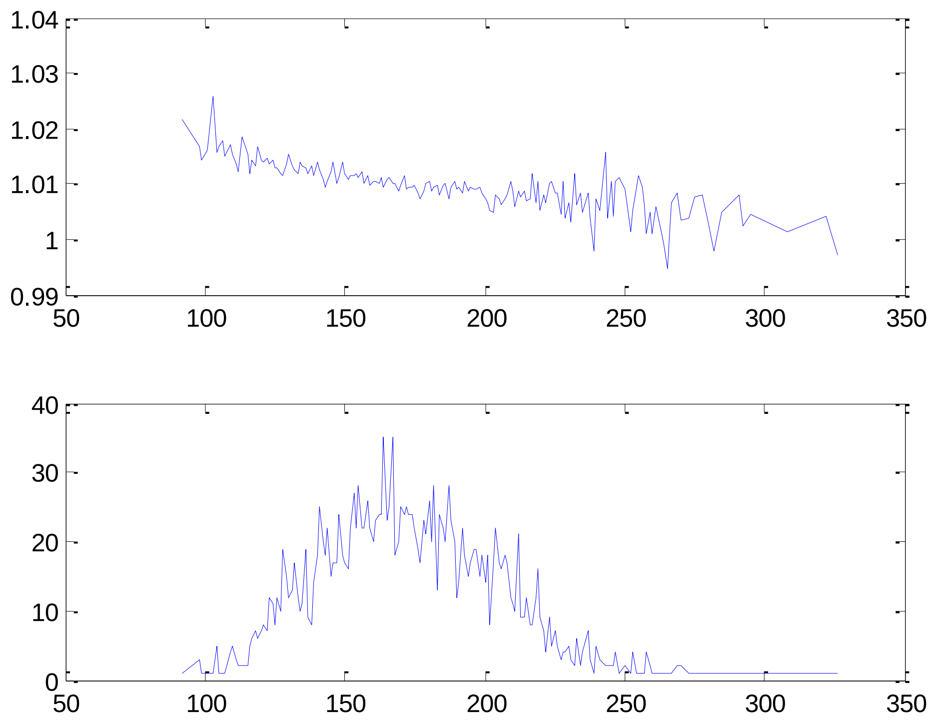
```
% ----- load in initial data -----
load dow.dat;
load usgb.dat; lusgb = length(usgb);
load usgb2.dat; lusgb2 = length(usgb2); % < Shiller's data from 1897 to 1972: http://www.econ.yale.edu/~shiller/data.htm

% ----- format the data: output is hreturn matrix and hreturn_size -----
% since dow data is bigger than bond data, remove dow data beyond bond data
tempbond = datenum([usgb(:, 3) usgb(:, 1) usgb(:, 2)]); % bond... convert to yyyy-mm-dd
for i = 1:length(dow)
 if dow(i, 1) > tempbond(end) dow = dow(1:i, :); break; end
end

hreturn = zeros(2, length(dow) - 1);
hreturn_size = length(hreturn);

temp = datevec(dow(:, 1));
temp = temp(:, 1) - temp(1, 1) + 1;
% load in 1 year US government bond data.
j = 1;
for i = 1:lusgb2 % <-- yearly data
 while (temp(j) <= i) hreturn(2, j) = usgb2(i) / 100; j = j + 1; end
end
temp = datenum(datevec(dow(:, 1))); % stock...
cur_rate = hreturn(2, j-1);

i = 1;
for k = j:hreturn_size
 % if the stock date is bigger or equal to the next bond rate,
 % set the current bond rate as the next bond rate.
 if (temp(k) >= tempbond(i+1)) i = i + 1; cur_rate = usgb(i, 4)/100; end
 hreturn(2, k) = cur_rate;
end

hreturn(1, :) = log(dow(2:end, 2)) - log(dow(1:end-1, 2)); % convert historical dow prices into logarithmic returns.
clear dow tempbond i j k cur_rate lusgb lusgb2 usgb usgb2 temp tempbond
```

```
plot(1:hreturn_size, (hreturn(2, :)*1000))

% ----- set up the initial variables -----

port_base = 2000; % < portfolio starting value
iterations = 2000;
tsize = 200; % determines number of trials per mean/risk point.
thorizon_mean = 40;
thorizon_std = .2 * thorizon_mean;
thorizon_maxd = .75 * thorizon_mean;
tstrikeprice_mean = 1;
tstrikeprice_std = .2 * tstrikeprice_mean;
tstrikeprice_maxd = .4 * tstrikeprice_mean;
use_historical_data = 1; % 1 means “yes”, any other value means “no”.
use_regular_stocks = 1; % …
use_vanilla_options = 1; % …
use_asian_options = 1; % …
use_fixed_horizon = 2; %…
use_fixed_strikeprice = 2; %…
conf_interval = .95;

% ----- start the simulation -----

conf_interval_inv = 1 - conf_interval;
srisk = zeros(3, iterations);
sreturn = zeros(3, iterations);
treturn = zeros(1, tsize);

% generate a normally distributed distribution of horizons, with an absolute minimum horizon value.
if (use_fixed_horizon == 1)
 thorizon(1:iterations) = thorizon_mean;
else
 thorizon = round(randn(1, iterations) * thorizon_std + thorizon_mean);
 thorizon = max(thorizon, thorizon_mean - thorizon_maxd); % cut off thorizon at a certain absolute maximum.
 thorizon = min(thorizon, thorizon_mean + thorizon_maxd); % cut off thorizon at a certain absolute minimum.
end

% vary the strike prices, too.
if (use_fixed_strikeprice == 1)
 tstrikeprice(1:iterations) = tstrikeprice_mean;
else
 tstrikeprice = round(randn(1, iterations) * tstrikeprice_std + tstrikeprice_mean);
 tstrikeprice = max(tstrikeprice, tstrikeprice_mean - tstrikeprice_maxd);
 tstrikeprice = min(tstrikeprice, tstrikeprice_mean + tstrikeprice_maxd);
end
% get the mean of each distribution and its return, and put that into an array.
for i = 1:iterations
 asianoptreturntot = .1;
 for j = 1: tsize
  if (use_historical_data == 1)
   % generate a return path for the stock.
   treturn_pathend = round(rand(1, 1) * (hreturn_size - thorizon(i))) + thorizon(i);
   treturn_path = hreturn(1, (treturn_pathend - thorizon(i) + 1):treturn_pathend);
   if ((use_vanilla_options == 1) | (use_asian_options == 1)) tbond_return = mean(hreturn(2, (treturn_pathend - thorizon(i)
+ 1):treturn_pathend)); end
  else
 % “sample”does not work with logs… needs whole numbers!
   treturn_pathnums = round(rand(1, thorizon(i))*hreturn_size);
   treturn_path = hreturn(1, treturn_pathnums);
   if ((use_vanilla_options == 1) | (use_asian_options == 1)) tbond_return = mean(hreturn(2, treturn_pathnums)); end
 end
  standard_returns = cumprod(exp(treturn_path)); % convert the log returns to a cumulative gains percentage.
```

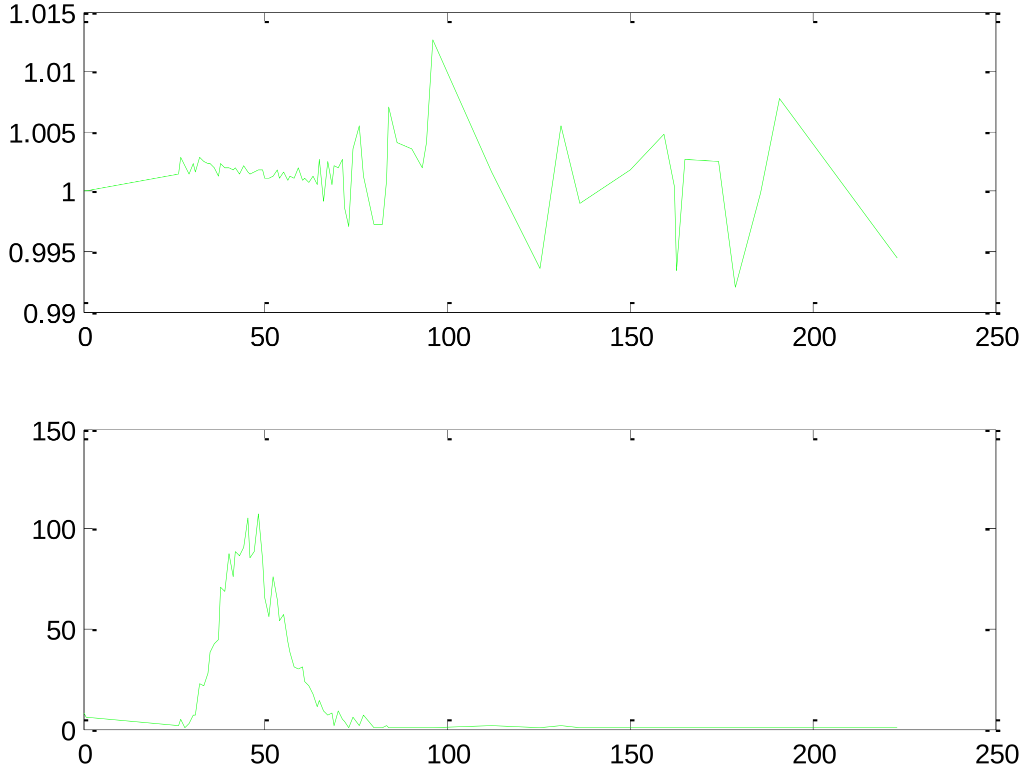
```
  % determine the price of Asian/vanilla options using the Black-Scholes “callput” program.
  if (use_vanilla_options == 1) [coption, poption, delta] = callput(1, tstrikeprice(i), 15.8114 * std(treturn_path), tbond_return, thorizon(i)/250); end

  if (use_asian_options == 1)
   % the Asian option price is determined by the mean of previous prices in the same iteration or trial set.
   asianoptprice = exp(-tbond_return*thorizon(i)/250)*asianoptreturntot/j;
   asianoptreturn = max(tstrikeprice(i) - mean(standard_returns), 0);
   asianoptreturntot = asianoptreturntot + asianoptreturn;
   treturn(3, j) = 1 + asianoptreturn - asianoptprice;
  end

  % calculate returns for regular stocks, vanilla put options, and Asian put options…
  if (use_regular_stocks == 1) treturn(1, j) = standard_returns(end); end
  if (use_vanilla_options == 1) treturn(2, j) = 1 + max(tstrikeprice(i) - standard_returns(end), 0) - poption; end

 end

 % now calculate the 80% etl and mean price of each portfolio.
  treturn =  treturn .^ (thorizon_mean/thorizon(i)); % I can’t separate this out for some reason…
 if (use_regular_stocks == 1) sreturn(1, i) = mean(treturn(1, :)); end
 if (use_vanilla_options == 1) sreturn(2, i) = mean(treturn(2, :)); end
 if (use_asian_options == 1)  temp = treturn(3, round(end/2):end); sreturn(3, i) = mean(temp); end

 if (use_regular_stocks == 1) srisk(1, i) = 1 - mean(treturn(1, (treturn(1, :) < quantile(treturn(1, :), conf_interval_inv)))); end
 if (use_vanilla_options == 1)  srisk(2, i) = 1 - mean(treturn(2, (treturn(2, :) < quantile(treturn(2, :), conf_interval_inv)))); end
 if (use_asian_options == 1)  srisk(3, i) = 1 - mean(temp(temp < quantile(temp, conf_interval_inv))); end
end

% ----- plotting stuff ----- first: regular plot
hold; plot(srisk(1, 1:length(srisk)), sreturn(1, 1:length(sreturn)), 'b.');
plot(srisk(2, 1:length(srisk)), sreturn(2, 1:length(sreturn)), 'g.');
plot(srisk(3, 1:length(srisk)), sreturn(3, 1:length(sreturn)), 'r.'); hold; waitforbuttonpress;

% in relation to stocks…
temp = sreturn(1, 1:length(sreturn)); hold; plot(srisk(1, 1:length(srisk)), 1, 'b.'); % < no horizon adjustment
plot(srisk(2, 1:length(srisk)), sreturn(2, 1:length(sreturn))/temp, 'g.');
plot(srisk(3, 1:length(srisk)), sreturn(3, 1:length(sreturn))/temp, 'r.'); hold; waitforbuttonpress;

% create plots to determine densities of observed observations
cols = ['b' 'g' 'r']; for k = 1:3
smin = round(min(srisk(k,:))*1000); smax = round(max(srisk(k,:))*1000); srisk2 = round(srisk(k, :)*1000);
sreturn2 = sreturn(k, :); mrisk = 0; j = 0;
for i = smin:smax
 temp = sum(srisk2 == i);
 if (temp ~= 0)
  j = j + 1; mrisk(1, j) = mean(sreturn2(srisk2 == i)); mrisk(2, j) = temp; mrisk(3, j) = i;
 end
end

% plot the risk levels
subplot(2, 1, 1)
plot(mrisk(3, :), mrisk(1, :), [cols(k) '.']);
plot(mrisk(3, :), mrisk(1, :), cols(k));

% plot the observations
subplot(2, 1, 2)
plot(mrisk(3, :), mrisk(2, :), [cols(k) '.']);
plot(mrisk(3, :), mrisk(2, :), cols(k));
waitforbuttonpress
end
hold
```



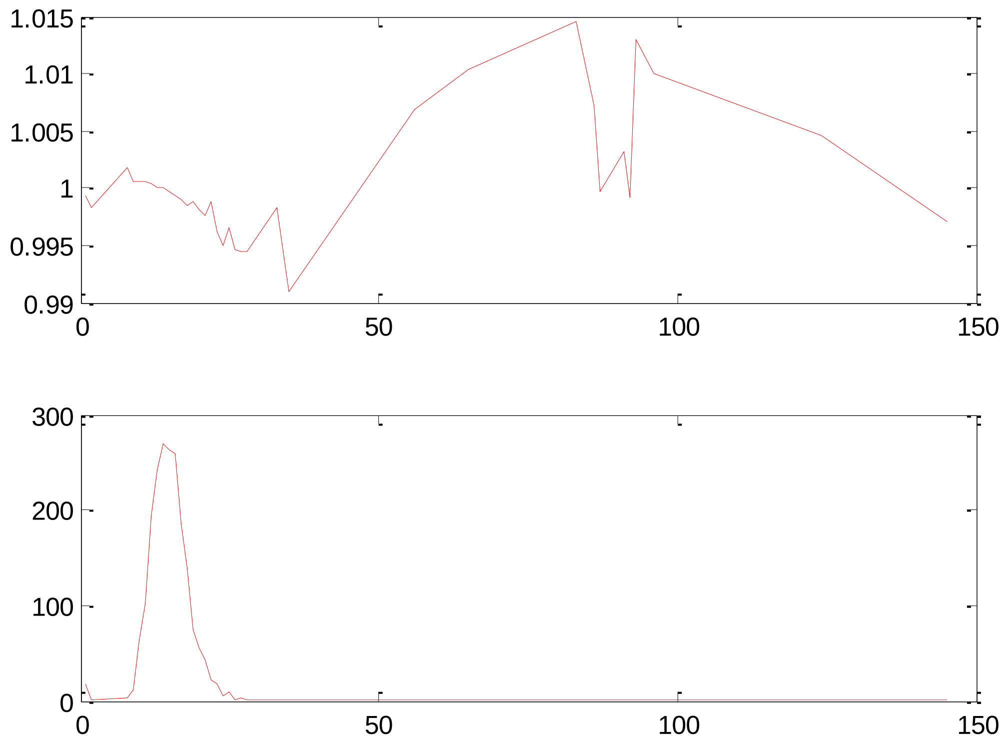
Risk versus return for Dow stock portfolio: the lower the return, the higher the risk!
(Risk and return is standardized over 40 days)



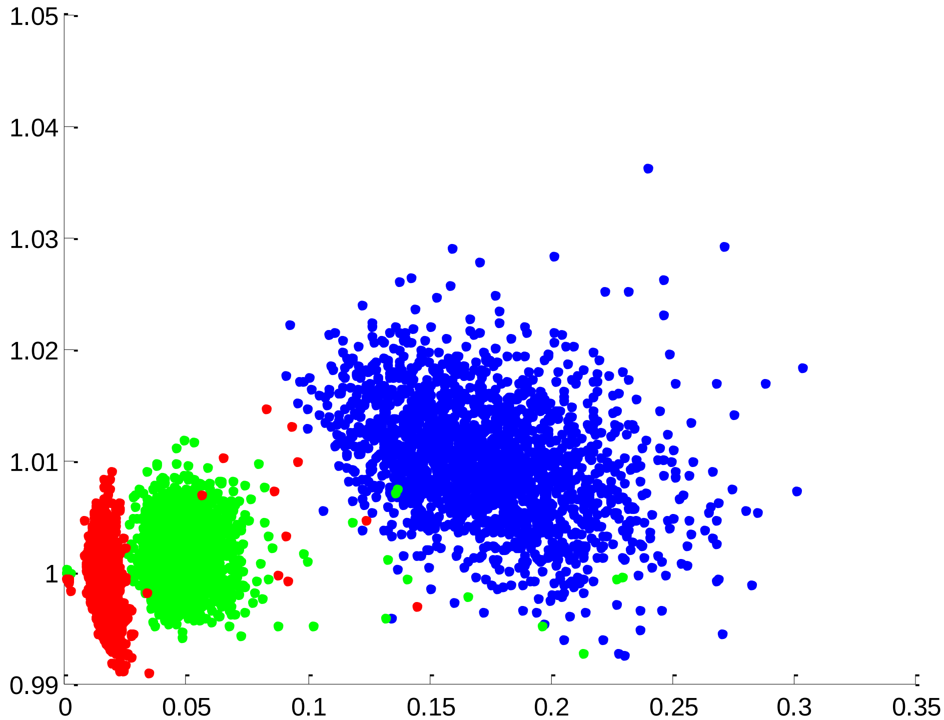
Top: risk v. return for regular stock, averaged per risk level. (200 = ETL of 20 on a portfolio of value 100) Risk decreases with increasing return.
Bottom: risk versus observations. (2000 observations)



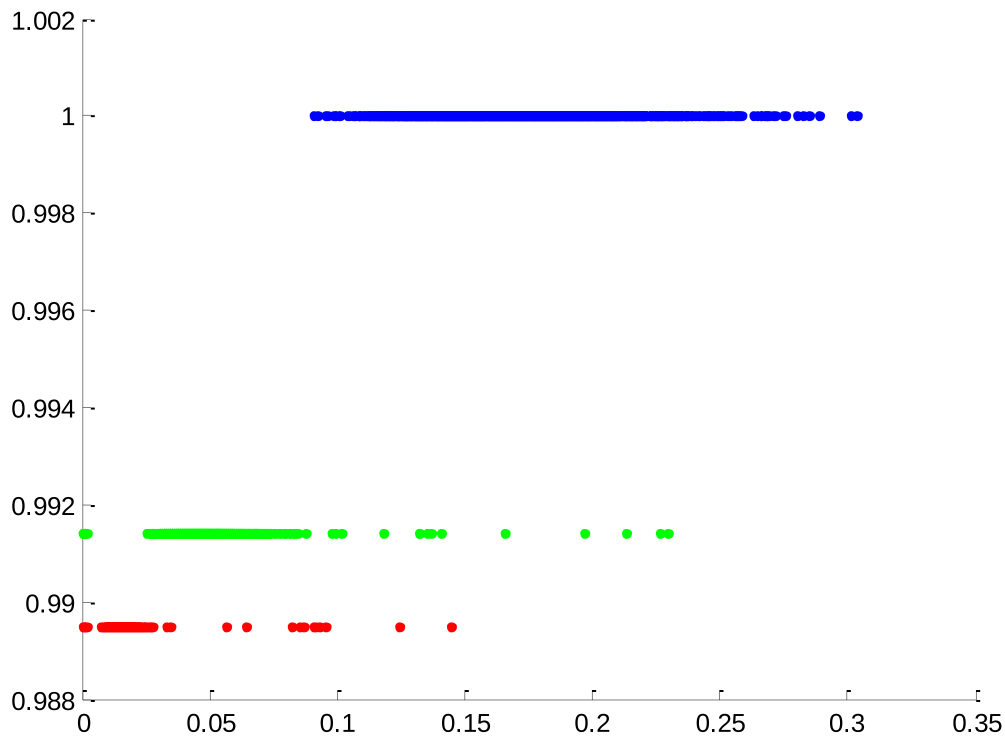
Same as above, but with vanilla options. Risk decreases (slightly) with increasing return.



Same as in above, but with Asian options. Risk also decreases with increasing return.



Asian options. Green = vanilla options. Blue = regular stocks.



A comparison of returns through the same trial sets shows a constant ratio of stocks to vanilla options and to Asian options, and shows the hypothesized risk-return tradeoff.