Exercises

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Agenda

- Portfolio exercises
- Exercises in asset pricing

Porteføljemuligheter med to aktiva

- $E(R_1)=0.01$, $\sigma(R_1)=0.01$
- $E(R_2)=0.015$, $\sigma(R_2)=0.02$
- $Cov(R_1,R_2) = 0.0002$

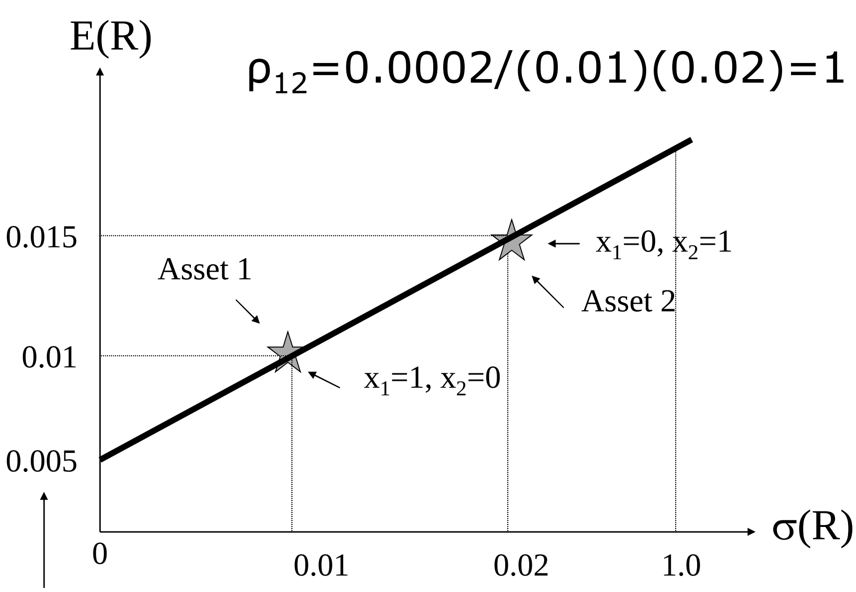
(i) Vis porteføljemulighetene (E-σ diagram)

(ii) Vil begge aktiva bli holdt i likevekt?

(iii) Hva er den laveste forventede avkastningen risikoaverse investorer vil akseptere? Hvilke andeler av aktiva 1 og 2 vil bli holdt I dette minimumspunktet?

(iv) Anta at et tredje, risikofritt aktivum med rente 0.007. Vis porteføljemulighetene nå. Er denne situasjonen konsistent med likevekt?

$$\rho_{12}=0.0002/(0.01)(0.02)=1$$



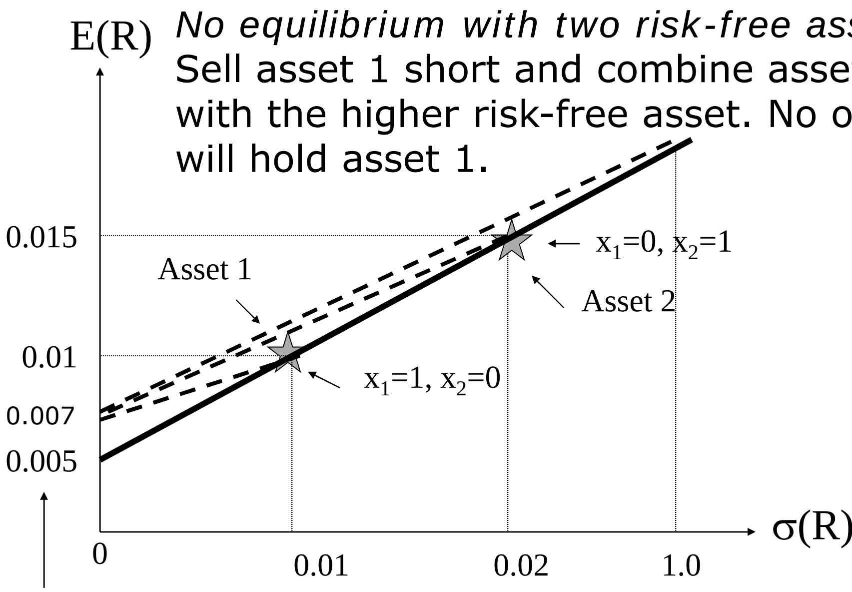
Risk-free return for $x_1= 2$ and $x_2= 1-2=-1$

(iii): Why R_F=0.005?

Let x_1=x and x_2=1-x
Porfolio return: $R_p = xR_1 + (1-x)R_2$
Expected return: $E(R_p) = xE(R_1) + (1-x)E(R_2)$
Variance: $\sigma^2(R_p) = x^2\sigma^2(R_1) + (1-x)^2\sigma^2(R_2)$
$+2x(1-x)\ \rho_{12}\sigma(R_1)\sigma(R_2)$
$\sigma^2(R_p) = [x\sigma(R_1) + (1-x)\sigma(R_2)]^2$
Standard deviation: $\sigma(R_p) = \pm[x\sigma(R_1) + (1-x)\sigma(R_2)]$

Risk-free rate: $\sigma(R_p)$= 0 for x= $\sigma(R_2)/[\sigma(R_2)-\sigma(R_1)]$=2
So: $E(R_F)$=2(0.01)+(1-2)(0.015)=0.02-0.015=0.005

No equilibrium with two risk-free assets: Sell asset 1 short and combine asset 2 with the higher risk-free asset. No one will hold asset 1.

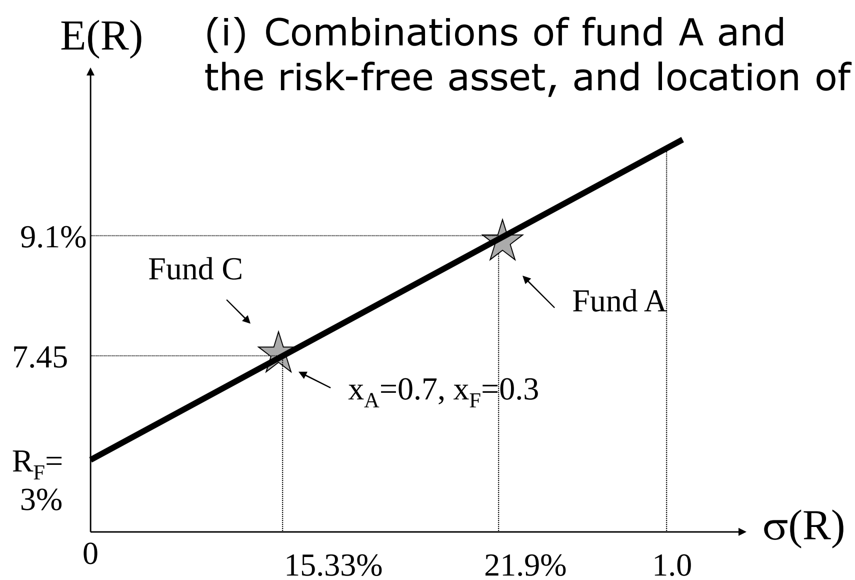


Risk-free return for x_1= 2 and x_2= 1-2=-1

Inefficient fund management

- Your pension fund C has the following asset allocation: (1) 70% invested in a value-weighted fund A consisting of all exchange traded shares, and (2) 30% in the risk-free asset
- There also exists a value-weighted bond fund B consisting of all risky bonds
- $E(R_A)=9.1\%$, $\sigma(R_A)=21.9\%$, V_A=MUSD 2
- $E(R_B)=3.6\%$, $\sigma(R_B)=5.6\%$, V_B=MUSD 1.5
- $\rho_{12} = 0.16$
- Risk-free asset F: $R_F=3\%$

(i) Combinations of fund A and the risk-free asset, and location of C



(i) The (A,F) portfolio line

Let x_A=x and x_F=1-x
Porfolio return: $R_p = xR_A + (1-x)R_F$
Expected return: $E(R_p) = xE(R_A) + (1-x)E(R_F)$
Standard deviation: $\sigma(R_p) = x\sigma(R_A)$
So: $x = \sigma(R_p)/\sigma(R_A)$
If we plug this x-value into the expected return equation and rearrange, we get:

$E(R_p) = R_F + [[E(R_A) - R_F]/ \sigma(R_A)]*\sigma(R_p)$
$= 3 + 0.2785\sigma(R_p)$

(ii) The capital market line

- $E(R_M) = (V_A/V_M)E(R_A) + (V_B/V_M)E(R_B)$ = 6.74%
- $\sigma^2(R_M) = (V_A/V_M)^2\sigma^2(R_A) + (V_B/V_M)\sigma^2(R_B)$
  $+2(V_A/V_M)(V_B/V_M)\rho_{12}\sigma(R_A)\sigma(R_B)$
  =171.978%
- $\sigma(R_M)$=13.11
- $E(R_M) = R_F + [[E(R_M) - R_F]/ \sigma(R_M)]*\sigma(R_p)$
  $= 3\% + 0.285\sigma(R_p)$
- Why does not pension fund C lie on this line?

(iii) The security market line

- $E(R_i) = R_F + \beta[E(R_M) - R_F]$, where $\beta = Cov(R_p, R_M)/\sigma^2(R_p)$
- $E(R_i) = 3\% + \beta[6.74\% - 3\%] = 3\% + 3.74\beta$
- $\beta_C = [E(R_C) - 3\%]/3.74 = 1.14$

Optimal portfolio weights

- Anta forventning-varians preferanser, dvs. investorer verdsetter en portefølje eller et aktivum basert på avkastningens forventning og varians (evt. standardavvik).
- Anta at den risikofrie renten er 10% og at det eksisterer to aktiva, A og B, med forventet avkastning E(R) og standardavvik $\sigma(R)$ som følger:
  - $E(R_A) = 0.20$ og $\sigma(R_A) = 0.30$
  - $E(R_B) = 0.25$ og $\sigma(R_B) = 0.40$

Q1

- Dersom du kan kombinere kun ett av de to risikable aktivaene med det risikofrie, hvilket ville du velge?
- A: Velg aksjen med den høyeste Sharpe-ratio (SR), dvs. aksje B:
  - SR_A = (.20 - .10)/.30 = .333
  - SR_B = (.25 - .10)/.40 = .375

Q2

- Anta at du nå kan kombinere begge de risikable aktivaene med det risikofrie. Hvilke porteføljevekter velger du?
- A: Anta at avkastningen på aksjene A og B ikke er korrelerte med hverandre, og finn portføljevektene ved å bruke "excess return over variance" regelen:
  - v(A) = (.20 - .10)/$.30^2$ = 1.1111
  - v(B) = (.25 - .10)/$.40^2$ = .9375
  - Standardiserer
  - %v(A) = 1.111/(1.111+.9375) = 54%
  - %v(B) = .9375/(1.111+.9375) = 46%

Q3

- Oslo Børs totalindeks har en verdi på $100 milliarder
- Du holder en portefølje hvor 90% er investert i OB indeksen og 10% i det risikofrie aktivum.
  - $E(R_{OBI}) = 15\%$. $\sigma(R_{OBI}) = 20\%$, og $r_F = 5\%$
- Du får vite at et <u>nytt</u> selskap har gått på børsen med en totalverdi på $2 milliarder.
  - Avkastningen til det nynoterte selskapet er uavhengig av OB indeksen og har et standardavvik på 40%.

Q3…

- Du ønsker å inkludere det nynoterte selskapet i din portefølje
- Hvilken vekt gir du det nye selskapet?
- Hva er den forventede avkastningen på det nynoterte selskapet's aksjer?

Q3…hvilken vekt?

- Anta at Oslo Børs prises ifølge Kapitalverdimodellen (CAPM)
- Ifølge CAPM holder investorene markedsporteføljen med verdiveiede vekter.
- Det nynoterte selskapet (NY) skal altså holdes med en vekt 2/102 = 1.96%
- Det ”gamle” OB markedet har vekt 98.04% i den nye markedsporteføljen

Q3…hva er forventet avkastning?

- Beregn optimal vekter ved ”excess return over variance” regelen:
  - v(gammel OB) = $(.15 - .05)/.20^2 = 2.50$
  - v(NY) = $[E(R_{NY}) - .05]/.40^2$

Q3…

- Siden vi skal ha veridiveiet vekt:
  - v(NY)/[v(NY)+v(gammel OB)] = .0196\
  Omgjort:
  - v(NY)(1-.0196) = v(gammel OB) x .0196
  Plugg inn fra forrige side:
  - v(gammel OB) x .0196= 2.5 x .0196 =.05
  Dvs:
  - v(NY) = .05/(1-.0196) = .05
  Dermed:
  - $[E(R_{NY})- .05]/.40^2 =.05$
    $E(R_{NY})- .05 = .05 \times .16,$
    $E(R_{NY}) = .008 + .05 =$ <u>5.8%</u>

Descriptive statistics (AFAP06-S3-Amazon.xls)

- Descriptive data based on daily stock returns of Amazon.com and Intel Corp., from May 1997 (start of Amazon) to December 1999
  - Provide descriptive statistics
    - Mean. standard deviation, kurtosis, skewness, etc.
  - Estimate and plot annual volatility
  - Use Excel's Descriptive Statistics function [under Tools, e.g. function=stdev(), function=correl()]
  - Plot the 20-day rolling window estimates for volatility (notice the variability)
  - How would you determine whether the variability in volatility is simply due to chance (random walk)?

AMZN, descriptive stats

- Amazon: 1997-05/06 – 1999-12/31
  - Annual return: 184%!
  - Volatility (SD): 97%.
  - Standard Error from estimating Mean over rolling 60-days

Descriptive Statistics (Daily returns)	
Mean	0.007386
Standard Error	0.002387
Median	0
Mode	0
Standard Deviation	0.061475
Sample Variance	0.003779
Kurtosis	1.220198
Skewness	0.465572
Range	0.434896
Minimum	-0.20909
Maximum	0.225806
Sum	4.896966
Count	663
Confidence Level(95.0%)	0.004688

Downside risk

- <u>Skewness</u>: third central moment of a random variable
  - Measures asymmetry
  - Skew = 0 for Normals
  - Evidence of positive skewness in data.
- <u>Kurtosis</u>: fourth central moment of a r.v.
  - Measures “fatness” of tails of distribution.
  - Kur = 3 for Normals.
  - Evidence of “fat-tails” in stock price data.

Converting daily returns to yearly

- $E(R_a)$ = (trading days) $E(R_d)$
- $\sigma(R_a)^2$ = (trading days) $\sigma(R_d)^2$

- Trading days: 250.

- AMZN mean: 0.007386 * 250 = 1.84
- AMZN SD: 0.061475 * $(250)^{1/2}$ = 0.97

Confidence interval for the Mean

- Daily data: 1.96 SE to the right and left of point estimate of 0.007386.
- Annual data
  - LHS = 0.007386 – 1.96(0.002387) = 0.002707
    - Or 0.6766 in annual terms.
  - RHS = 0.012066
    - Or 3.016 in annual terms.
- Statistically conclude: E(r) in [0.6766, 3.016].

The problem

- Should we use 184% in our expected return formula?
  - Huge standard errors
- This is the main difficulty with mean-variance analysis:
  - Hard to estimate the most important parameters (the means)
  - Need ways to improve our estimates of expected returns
- More frequent sampling of data (daily, intra-daily) does not improve standard errors for the means

Volatility estimation

- "Volatility" = standard deviation
- Standard errors for volatility estimates CAN be improved upon by sampling more frequently
- Using the options market's implied volatilities are also a good idea

Implied volatility (ISD)

- Ideal estimator: forward looking
- Option markets help in determining ex-ante estimates for the volatilities of assets
  - Invert Black-Scholes formula (typical)
  - Or more complicated asset-pricing model which has volatility as an implicit parameter
- ISD vs historical estimation?
  - It seems both implied volatilities and historical estimates have predictive power

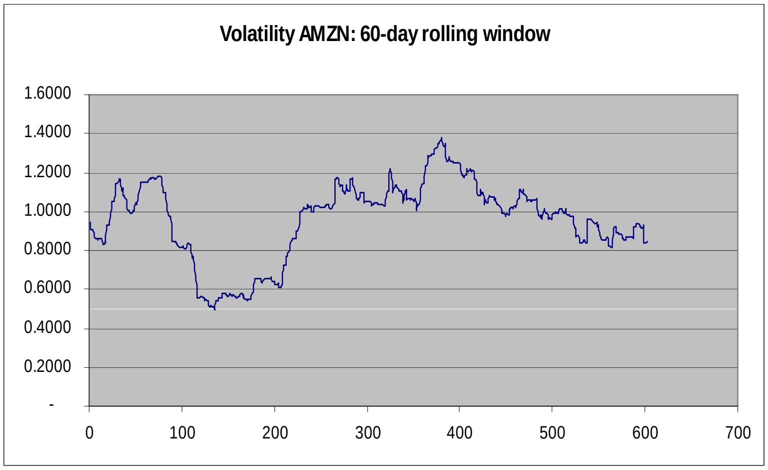
Improvements on historical estimates

- Weighted rolling window
  - Use "decay rates" to weight more heavily recent observations
- Overlapping returns
- Optimal decay rates
- Mixture of normals:
  - low- and high- volatility states
  - get fat tails
  - estimate using maximum likelihood

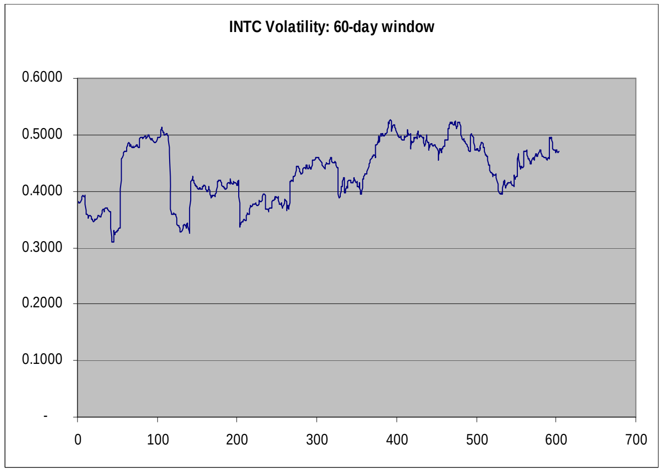
Non-stationarities

- Were volatilities and correlations constant?
- Point estimates:
  - AMAZON (AMZN): 97.2%
  - INTEL (INTC): 43.5%
- Max and min 60-day rolling window estimates:
  - AMZN: 49.8%-137%
  - INTC: 30.9%-52.5%
- Correlation: 0.22 (min –0.14, max 0.55)

AMZN volatilities



INTC Volatility



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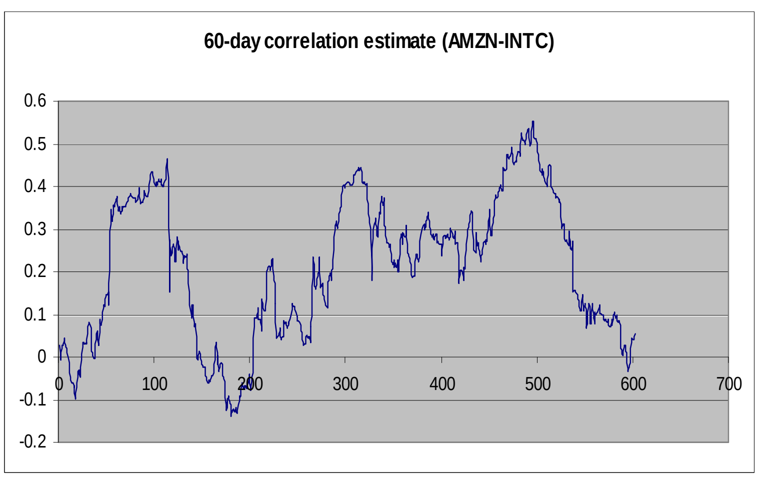
Correlations INTC-AMZN



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Simulations of volatility

- Graphs show that volatility moves around, but it could be just due to randomness in a standard random walk model. How can we tell it was not random? Requires simulations
- Generate 3 years of "simulated" daily returns (using means and vols from data)
  - Use spreadsheet to generate a normal r.v.
- Then calculate 60-day rolling window estimates for the simulated data
- Idea: compare these estimates to those from the data
- Would like to do these simulations many times (for comparison to be meaningful)

Simulations, cont'd

- I focused on max, min and (max-min)
- Data is significantly different from simulated statistics
  - AMZN: 49.8%-137% range for 60-day RW vols. Difference of 88%
  - Simulated data: largest difference (after 1000 simulation) was 39%

Time Horizons

- Standard estimators based on daily data
  - But timeframe may be years
- Using standard estimators in mean-variance analysis will cause sub-optimal decisions
- VAR (vector auto-regression) captures
  - time-variation (as in mean-reverting model)
  - stochastic correlation (changes with the states of the economy)

Decritive statistics – stock indices (AFAP06-S3-NYSEAMEXNASDAQ.xls)

- The file provides data on the stock returns to NYSE, AMEX, and NASDAQ value-weighted indices
- (a) Estimate the variance-covariance matrix and the expected returns to the three indices (in annual terms)
- (b) Based on the estimates in (a), what are the optimal portfolio of the three indices when the riskfree rate is 5%?
- A: w_{NYSE}=99.3%, w_{AMEX}=-406, w_{NASDAQ}=407%
- (c) What are the weights if short-sales constraint?
- A: w_{NYSE}=30.6%, w_{NASDAQ}=69.4%. This portfolio may be preferable if short-selling is very costly

Descriptive Stats – indices

Negative skewness.

Excess kurtosis.

Median above mean.

	NYSE	AMEX	NASDAQ
Mean	**0.061%**	**0.039%**	**0.097%**
Standard Error	0.016%	0.013%	0.022%
Median	**0.059%**	**0.079%**	**0.147%**
Mode	#N/A	0.141%	-0.173%
Standard Deviation	0.794%	0.644%	1.130%
Sample Variance	0.0001	0.0000	0.0001
Kurtosis	**5.4002**	**9.9358**	**4.2729**
Skewness	**(0.3946)**	**(1.0251)**	**(0.4245)**
Range	10.979%	10.437%	14.710%
Minimum	-6.391%	-6.227%	-8.695%
Maximum	4.589%	4.209%	6.015%
Sum	2	1	2
Count	2,528	2,528	2,528

Descriptive Stats: DJIA stocks

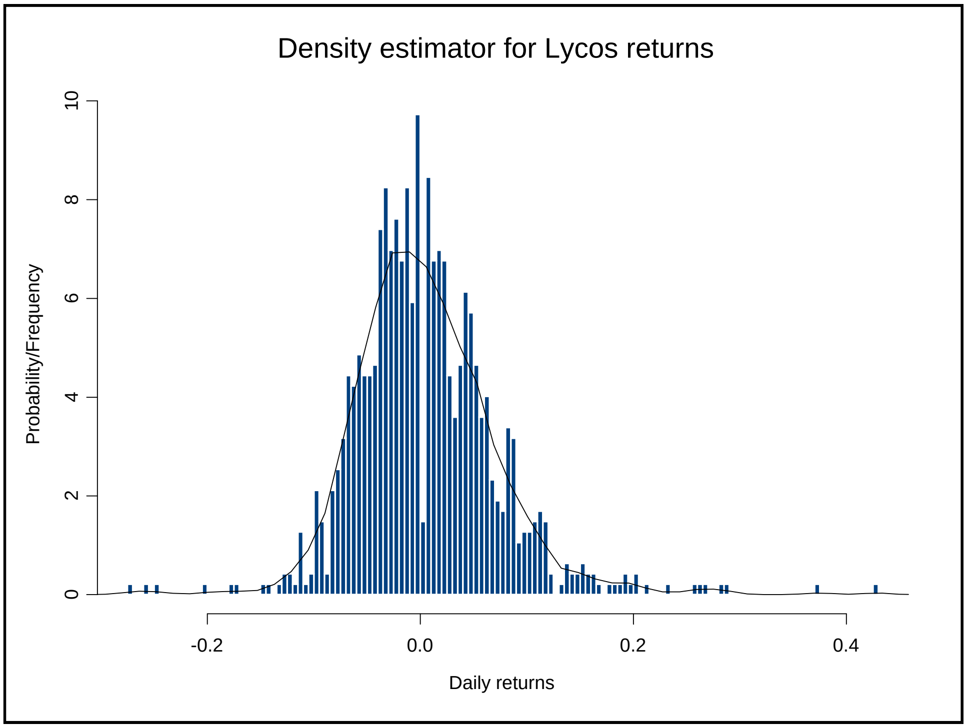
	AXP	*MMM*	*UTX*	*PG*	*S*
Mean	**0.098%**	**0.066%**	**0.076%**	**0.086%**	**0.065%**
Standard Error	0.029%	0.020%	0.023%	0.021%	0.027%
Median	**0.000%**	**0.000%**	**0.000%**	**0.000%**	**0.000%**
Mode	0.000%	0.000%	0.000%	0.000%	0.000%
Standard Deviation	2.096%	1.452%	1.643%	1.514%	1.898%
Sample Variance	0.044%	0.021%	0.027%	0.023%	0.036%
Kurtosis	**8.377**	**23.718**	**3.492**	**30.306**	**9.971**
Skewness	**(0.154)**	**(1.091)**	**0.004**	**(0.416)**	**(0.124)**
Range	44.786%	37.517%	25.721%	49.200%	44.241%
Minimum	-26.230%	-25.979%	-15.681%	-27.000%	-25.301%
Maximum	18.557%	11.539%	10.040%	22.200%	18.939%
Sum	5	3	4	4	3
Count	5,055	5,056	5,056	5,056	5,056
Largest(1)	18.557%	11.539%	10.040%	22.200%	18.939%
Smallest(1)	-26.230%	-25.979%	-15.681%	-27.000%	-25.301%
Confidence Level(95.0%)	0.058%	0.040%	0.045%	0.042%	0.052%

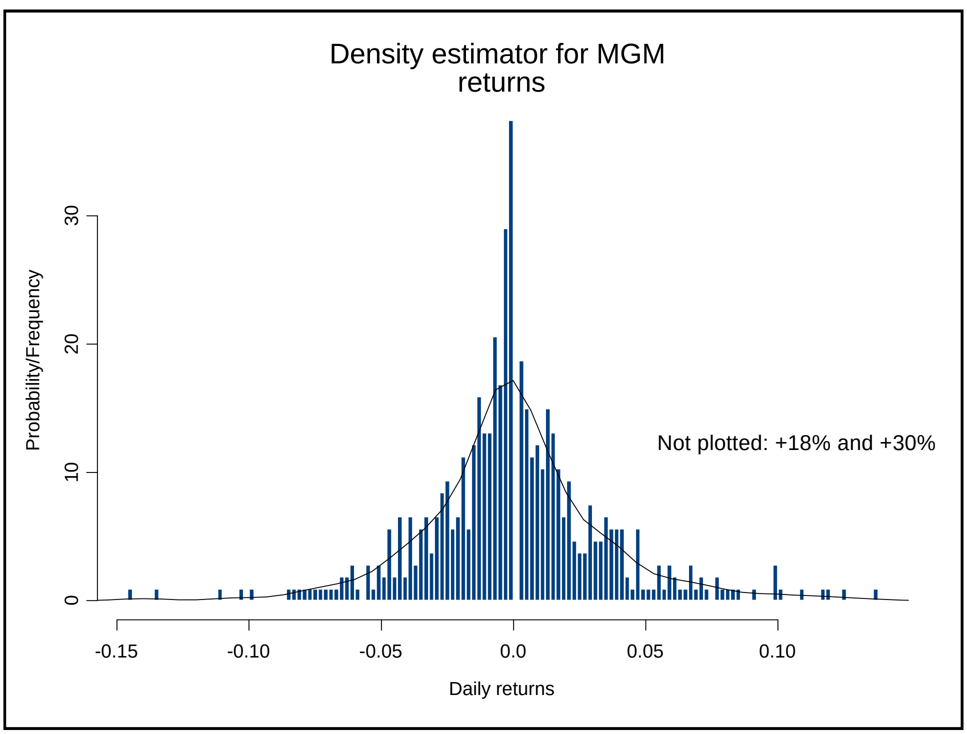
Descriptive Stats: other stocks
[in AFAP03-Exercise 2 (firm data).xls]

	LCOS	*MGM*	*Sony*	*Yahoo*
Mean	0.4957%	0.1142%	0.0844%	0.5908%
Standard Error	0.2154%	0.1620%	0.0359%	0.1647%
Median	0.0000%	0.0000%	0.0000%	0.0000%
Mode	0.0000%	0.0000%	0.0000%	0.0000%
Standard Deviation	6.6237%	3.7508%	1.8050%	5.0473%
Sample Variance	0.4387%	0.1407%	0.0326%	0.2547%
Kurtosis	**4.3674**	**8.6784**	**3.6789**	**1.8199**
Skewness	**0.8743**	**1.1927**	**0.6194**	**0.5479**
Range	70.19%	43.45%	18.67%	44.03%
Minimum	-27.41%	-14.41%	-8.78%	-20.11%
Maximum	42.78%	29.03%	9.88%	23.93%
Sum	5	1	2	6
Count	946	536	2,528	939
Confidence Level(95.0%)	0.004226293	0.0031825	0.000704	0.0032324

Estimating "shapes"

- Estimates of downside risk try to assess the shape (and size) of tails of a distribution
- More general estimates of distributions: graphical displays of density function (estimates) with histograms
- Get picture of shape of distribution (asymmetries and fat-tails easily identified)


Density estimator for Lycos returns
Probability/Frequency
0
2
4
6
8
10
-0.2
0.0
0.2
0.4
Daily returns


Density estimator for MGM returns
Probability/Frequency
0
10
20
30
Not plotted: +18% and +30%
-0.15
-0.10
-0.05
0.0
0.05
0.10
Daily returns

Value-at-Risk

- VaR (95) = $3 means "with 95% probability portfolio will lose at most $3" or "with 5% prob. portfolio will lose more than $3"
  - Single number that describes downside risk
  - Supported by regulators
  - Extreme type of position: only care about probability of large loss
  - Is this type of risk priced? If so, how?

Agenda

- Portfolio exercises
- Exercises in asset pricing

Exam-02-Q2(a)

- Under antagelsene bak kapitalverdimodellen (CAPM) så holder investorene porteføljer som består av kobinasjoner av markedsporteføljen og det risikofrie aktivum. Anta nå at det ikke eksisterer et risikofritt aktivum. Betyr dette at alle investorene ganske enkelt holder markedsporteføljen? Forklar med et diagram. Er markedsporteføljen fremdeles forventning-varians effisient?

Q2(a)

- It does not follow that every investor holds the market. Investors can choose any portfolio on the top half of the minimum variance frontier. The market is a positively weighted combination of everyone's portfolio. Since positively weighted combinations of portfolios on the top half of the minimum variance frontier remain on the top half of the frontier, the market is in the set of portfolios investors might hold, and it remains mean-variance efficient.

Q2(b)

- I 1991 rapporterte Fama og French at den gjennomsnittlige avkastningen på såkalte ”value stocks” (dvs. aksjer med høyt bok-til-pris forhold) var høyere enn den gjennomsnittlige avkastningen på ”growth stocks” (dvs. aksjer hvor bok-til-pris forholdet er lavt) over perioden 1963-1990. Gi mulige forklaringer på denne observasjonen

Q2(b)

- Should one have expected a value effect before looking at the data? Is there a theoretical reason why ratios of a fundamental value to price (book-to-market, earnings/price, cashflow/price, etc.) should be related to expected return?
- The discount rate effect implies there should be a positive relation between expected return and the ratio of a fundamental, such as book value, earnings, or cashflow, to price. For example, if a firm has a high expected return – or, equivalently, a high discount rate – its price is low relative to its expected cashflows. If its current cashflow is a reasonable proxy for its expected cashflow, its cashflow to price ratio will be relatively high. Similarly, if it has a low expected return, its discount rate is low and its price is high relative to fundamentals
- How would you test whether the original evidence of a value effect is just a chance result of data mining? The best way by far is to look out of sample, such as other time periods or other countries

Q2(c)

Anta at du har identifisert følgende tre systematiske risikofaktorer: oljeprisen, inflasjon, og industriproduksjon (disse er de eneste riskofaktorene). Ved begynnelsen av året er den forventede veksten i disse faktorene henholdsvis 0%, 5% og 3%. Ved slutten av året viste det seg at den faktiske veksten over året var 2%, -4%, og –3%. Du holder en aksje som har en beta mot oljeprisen på 1.8, en beta mot inflasjon på 0.7, og en beta mot industriproduksjon på 1.0. Beregn aksjens totale realiserte avkastning over det året. Anta at aksjens forventede avkastning er 12% og at året ikke brakte noen selskaps-spesifikke nyheter om aksjen.

Q2(c)

$R = E(R) + \beta_{olje}[R_{olje} - E(R_{olje})] + \beta_{inflation}[R_{inflation} - E(R_{inflation})] + \beta_{IP}[R_{IP} - E(R_{IP})]$

$= 12 + 1.8 \times (2-0) + 0.7 \times (-4 - 5) + 1 \times (-3 - 3) = 3.3\%$

Q2(d)

- Investerings-selskapet Berkshire Hathaway, som drives av berømte Warren Buffet, har hatt høy avkastning over mange år. Dataene viser at, over perioden 1976 – 2001, hadde Berkshire faktisk en CAPM alpha på 1.61% pr. måned, og en Fama-French alpha på 1.17%. Begge mål på performance er mer enn tre standardavvik fra null. Betyr dette at aksjemarkedet er ineffisient? Diskuter

Q2(d)

Any test of market efficiency is simultaneously a test of the model of expected returns. If we dogmatically accept either the CAPM or the three-factor model, we can reject market efficiency. It is possible, however, that we have a bad model of the returns investors require.

Additional questions - 1

- Den 7. oktober 2001 hadde The Wall Street Journal følgende overskrift: "Top International Fund Puts Just a Few Eggs in Its Basket". Poenget i artikkelen var at det internasjonale fondet med den høysete realserte avkastningen i det foregående kvartal hadde kun 20 aksjer i fondsporteføljen. Overrasker dette deg? Forventer du at fondet med den beste realiserte avkastningen holder mange aksjer eller bare noen få? Forklar.
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A1

We expect the most extreme funds – whether the best-performing or the worst-performing – to be among the most volatile. Therefore, it is not surprising that the top fund is poorly diversified, with only 20 stocks. Similarly, we would expect the worst-performing fund to have relatively few stocks.

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Additional question - 2

- Anta at aksjemarkedet er drevet av kun to risikofaktorer, 1 og 2, og at standardavviket til begge faktorene er 2%. Du får oppgitt følgende Tabell om porteføljene A, C, D, G og H:

Portf.	E(r)	σ	β_1	β_2
A	9%	2%	1	0
C	11%	2√2= 2.8284%	1	1
D	4%	0	0	0
G		√2= 1.4142%	.5	.5
H		4%	.5	1

Hva er den forventede avkastningen på portefølje G?

A2

$E(R_i) = R_F + b_{i1}[E(R_{FMP1})-R_F] + b_{i2}[E(R_{FMP2})-R_F]$

- Vi trenger å finne verdiene på faktor-premiene $E(R_{FMP1})-R_F$ og $E(R_{FMP2})-R_F$
  slik at vi kan bestemme $E(R_G)$

Merk:

- Aktivum D er risikofritt, dvs. $R_F = E(R_D) = 4$
- Portefølje A er Faktor nr. 1, slik at
  $E(R_{FMP1}) - R_F = E(R_A) - R_F = 5\%$

A2, cont'd

Portf. C er høyt diversifisert, dvs. ren faktorportefølje

- $Var(R_C) = 1^2 Var(f_1) + 1^2 Var(f_2) + Var(e)$
- $8 = 1 \times 4 + 1 \times 4 + Var(e)$ dvs. $Var(e) = 0$

- $E(R_C) = R_F + b_{C1}[E(R_{FMP1})-R_F] + b_{C2}[E(R_{FMP2})-R_F]$
  $11 = 4 + 5 + [E(R_{FMP2})-R_F]$, so $E(R_{FMP2})-R_F = 2\%$

Portfefølje G er også en ren faktorportefølje :

- $Var(R_G) = 0.5^2 Var(f_1) + 0.5^2 Var(f_2) + Var(e)$
- $2 = .25 \times 4 + .25 \times 4 + Var(e)$ dvs. $Var(e) = 0$

- $E(R_G) = 4 + .5 \times 5 + .5 \times 2 =$ <u>7.5%</u>

AFAP06-IBM.xls

- Using the data in the excel file, estimate the constant term and slope coefficient (market beta) for IBM using the simple one-factor market model
- In this regression, use excess returns, i.e., subtract the short-term risk-free rate (e.g., variable 1-m) from the raw returns on both sides of the regression
- Use, alternately, the value-weighted market index (VW-m) and the equal-weighted index (EW-m)
- Report the coefficient estimates and their t-values. Place a star ("*") next to each coefficient estimate that is significantly different from zero at the 1% level of significance
- Report the adjusted regression R-squares.

IBM…

- Repeat the above using a long-term government bond rate (e.g., 20-y YTM) as the risk-free rate. Do you see any differences in the coefficient estimates? If so, why?

- Estimate the Fama-French three-factor model, i.e., using the factors VW-m, SMB and HML, for IBM. Both the left-hand side and the market index should be in the form of excess returns. Comment on the sign and significance of the parameter estimate, and the adjusted regression R-squares.

IBM…

- Estimate a multifactor model for IBM, using four factors
  - (1) the excess return on the value-weighted market,
  - (2) the short-term yield spread,
  - (3) the corporate bond spread (Cspread), and
  - (4) real per capita personal consumption growth (RPC).
- You can construct factor (2) by, e.g., the forming the difference (1-y YTM)-(3-m), and taking the first difference of this series. It is preferable to take the first difference of Cspread as well before this is entered into the regression.
- Comment on the coefficient estimates and their significance, as well as the adjusted R-squares.

Variable definition AFAP03-IBM.xls

- Date Date (month)
- VW-m Monthly return on NYSE/Amex/Nasdaq Value-Weighted Market Index
- EW-m Monthly return on NYSE/Amex/Nasdaq Equal-Weighted Market Index
- 1-m T-bill, Yield-to-maturity on 1-month T-bill
- 3-m T-bill, Yield-to-maturity on 3-month T-bill
- IBM Monthly return on IBM stocks
- SMB Monthly return difference between a portfolio of small stocks and a portfolio of large stocks (Fama and French, 1993)

- HML Monthly return difference between a portfolio of high book-to-market stocks and a portfolio of low book-to-market stocks (Fama and French, 1993)
- Inflation Monthly change in the Consumer Price Index (CPI)
- Real int. Real interest rate (1-month Tbill – inflation)
- 1-y YTM Yield-to-maturity on 1-year Treasury bonds
- 10-y YTM Yield-to-maturity on 10-year Treasury bonds
- 10-y YTM Yield-to-maturity on 20-year Treasury bonds

- RPC Real per capita growth rate of personal consumption
- UI Unanticipated inflation
- Cspread The yield spread between corporate bonds rated BAA and AAA

- All variables except UI and Cspread have observations for the period 19640131 – 19971231. UI has observations for 19640131 – 19931131, Cspread has observations for 19640131 – 19891229. The missing observations are coded using ‘.’