What is Risk?

- General Risk
- Market Risk
- Credit Risk
- Operational Risk
- Liquidity Risk
1. What is Value at Risk (VaR)?

- How do we measure risk normally?

\[ \sigma = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (r_i - \bar{r})^2} = \sqrt{E(r - E(r))^2} \]

Sensitivity Analysis, Monte Carlo Simulation...

- **VaR**: the estimated loss of an asset that, within a given period will only be exceeded by a certain small probability \( \theta \) (here: \( \theta = 5\% \)).
- \( \text{prob}[\text{return}_t < -\text{VaR}_t | \Omega_t] = \theta \)

- e.g. normal VaR: \( \text{VaR} = \mu + Z \cdot \sigma \) with \( Z = -1.65 \)
• Eurostoxx 50 returns from (01/01/1990 – 12/12/2007, 4697 Obs.)
Who uses VaR?

- VaR used for external purposes: Determines the minimum capital reserves

  Banks and other financial institutions are required to hold

- VaR used for internal purposes: control traders in their drive for risky investments. (see for instance bankruptcies of Barings or Metallgesellschaft who failed because of “Rouge Traders” and the lack of risk management)
Calculating VaR in EViews:

- foregoing observation period is often 250 or 500 days (trade-off between including all relevant information and unflexible VaRs); rolling estimation
- create a workfile containing your data
• open a new program. Later, set maximum errors before halting to a 999 to ignore ludicrous errors such as “log of negative number”.
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- other possible programs:

  C++  Gauss  R  Matlab

  TSP  Stata  RATS  SPSS

EViews

programming language not userfriendly

Userfriendly, sometimes irritating programming
wfopen C:\Zeno\VPC\snp_stoxx 'open your workfile

mode verbose 'here you can see what's going on while the program is running. Set to mode quiet to increase speed

tic 'starts the timer of the program

**************create variables that you want to use***************
scalar cpu_time 'a scalar where we will save the CPU time (in seconds) for running through the whole program
vector(4197) mean_dlstoxx
vector(4197) stdev_dlstoxx
vector(4197) nvar_dlstoxx
***************create variables that you want to use***************

for !i = 1 to 4197 '=(4697-500). Loop through the sample calculating rolling estimations
smpl 12/29/1989+!i 12/29/1989+(499+!i) 'loop through the sample
mean_dlstoxx(!i) = @mean(dlstoxx)
stdev_dlstoxx(!i) = @stdev(dlstoxx)
next

nvar_dlstoxx = mean_dlstoxx + @qnorm(0.05)*stdev_dlstoxx 'create normal VaR. This is still a 4197 vector and has to be transformed into a series later

mtos(nvar_dlstoxx, nvars_dlstoxx) 'mtos = matrix to series. In order to get a time axis and to create a graph, we have to use series instead of vectors

cpu_time = @toc

toc 'ends the timer of the program. With mode quiet this takes only 0.549 seconds on a P4 2400 Ghz.
Performance of the normal VaR:

- starts to decrease to late
- cannot capture the volatility clustering
- when hits occur then the losses are often very large
• **GARCH-VaR:** \( VaR = \mu + t \cdot \sqrt{h_t} \) (replace \( Z \) with \( t \) and the unconditional rolling standard deviation by the conditional standard deviation from a GARCH model)

with \( h_t = \omega + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1} \) (e.g. GARCH(1,1) or some other member of the GARCH family)

• **RiskMetrics, JP Morgan (1995):** \( VaR = \mu + Z \cdot \sqrt{\sigma_t} \)

with \( \sigma_t^2 = \lambda \sigma_{t-1}^2 + (1 - \lambda) r_{t-1}^2 \) and \( 0 < \lambda < 1 \). (This corresponds to an integrated GARCH model without constant and fixed parameters. Good if you suspect that the conditional standard deviation has no mean reverting property i.e. \( \alpha + \beta \) very close to one)
**Standardized residuals of GARCH(1,1) on Eurostoxx 50**

\[ f(x|\mu, \sigma) = \frac{1}{\sqrt{2\pi}\sigma} \exp\left( -\frac{1}{2\sigma^2}(x - \mu)^2 \right) \]

**Value at Risk models**

- **Kernel Normal (\(\mu=-0.01619, \sigma=0.9987\))**

**Standardized residuals not normally distributed**

- **Series:** RESID01
- **Sample:** 12/13/1990 12/31/2007
- **Observations:** 4448

- **Mean:** -0.016191
- **Median:** 0.007096
- **Maximum:** 5.124262
- **Minimum:** -11.84592
- **Std. Dev.:** 0.998650
- **Skewness:** -0.608931
- **Kurtosis:** 8.205739
- **Jarque-Bera:** 5297.365
- **Probability:** 0.000000
Standardized residuals can be much better approximated by a student's-t with dof around 7.

\[
f(x|\mu, \sigma, \nu) = \frac{\Gamma((\nu + 1)/2)}{\sigma \sqrt{\nu \pi} \Gamma(\nu/2)} \left[ \frac{\nu + ((x - \mu)/\sigma)^2}{\nu} \right]
\]

With \( \nu = 7.713 \),

\[
\Gamma(x) = \int_{z=0}^{\infty} z^{x-1} e^{-z} dz
\]
wfopen C:\Zeno\VPC\snp_stoxx 'open your workfile

mode quiet 'With the GARCH models running it is recommended to set the mode to quiet

tic 'starts the timer of the program

***************create variables that you want to use***********************
scalar cpu_time 'a scalar where we will save the CPU time (in seconds) for running trough the whole
program
vector(4197) mean_dlstoxx
vector(4197) stdev_dlstoxx
vector(4197) condsd_dlstoxx
vector(4197) nvar_dlstoxx
vector(4197) gvar_dlstoxx

**********************************************************************

for !i = 1 to 4197 ' = (4697-500). Loop trough the sample calculating rolling estimations

smpl 12/29/1989+!i 12/29/1989+(499+!i) 'loop trough the sample

mean_dlstoxx(!i) = @mean(dlstoxx)
stdev_dlstoxx(!i) = @stdev(dlstoxx)
equation eq1.arch(1,1,b, tdist) dlstoxx c 'GARCH(1,1) on dlstoxx with conditional t-distribution and
BHHH algorithm
eq1.makegarch condvariance_dlstoxx
condsd_dlstoxx(!i) = @sqrt(condvariance_dlstoxx(!i+499))

next

Zeno Adams
nvar_dlstoxx = mean_dlstoxx + @qnorm(0.05)*stdev_dlstoxx 'create normal VaR. This is still a 4197 vector and has to be transformed into a series later
gvar_dlstoxx = mean_dlstoxx+@qtdist(0.05,7)*condsd_dlstoxx

mtos(nvar_dlstoxx, nvars_dlstoxx) 'mtos = matrix to series. In order to get a time axis and to create a graph, we have to use series instead of vectors
mtos(gvar_dlstoxx, gvars_dlstoxx)

cpu_time = @toc

toc 'ends the timer of the program. With GARCH VaR this takes now 283.7 seconds on a P4 2400 Ghz.
Value at Risk models

Stoxx Returns
Normal VaR
GARCH VaR
Performance of the GARCH-VaR:

- Much better at following the return process over time
- Able to account for volatility clustering in the returns
- If hits occur, the risk manager is much better prepared and the losses are much lower.
- Increases in the VaR warns the risk manager in terms of high risk and volatility periods
What properties is a good VaR model supposed to have?

- When hits occur, they should be as small as possible
- During quiet periods, the VaR should decrease in order allocate capital reserves more efficiently
- A good VaR model reacts fast and effectively to changes in returns
- In a good 5% VaR, hits occur only 5% of all times (hitratio = 5%)

$$VPC = (1 - \theta) \cdot \frac{1}{n} \sum_{h=1}^{H} (hitvalue_h - VaR_h)^2 + \theta \cdot \sqrt{\frac{1}{n} \sum_{j=1}^{J} VaR_j - R_j} \cdot I(R_j < 0) + \gamma \cdot \rho + \delta \cdot |\theta - \text{ratio}|$$