ModelRisk
for Insurance and Finance

INFORMS

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Background

- Risk analysis techniques are getting more complicated;
- Often a lot of programming required;
  - Time-consuming;
  - Prone to errors
- Risk analysis modeling tool made by risk analysts
- Microsoft Excel still used most of the time;
  - See also next slide

ModelRisk

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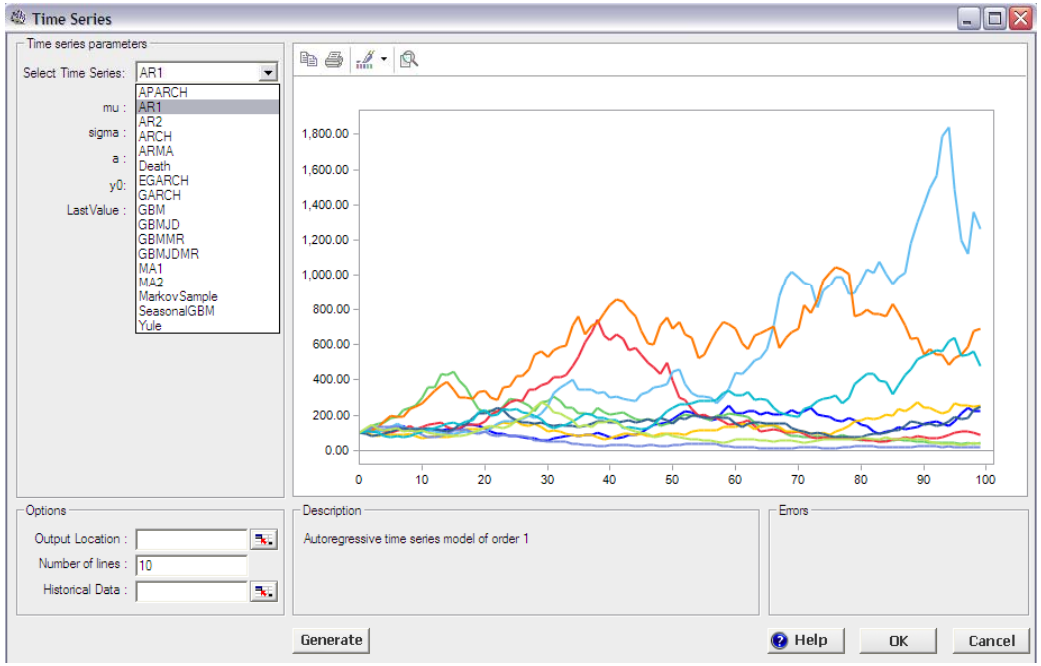
- What do 95% of professionals prefer?

```
N<-1000 a<-c(0.9,1) e<-
rnorm((N+1),0,1) u<-0 p1<-
rep(u,(N+1)) p2<-rep(u,(N+1)) for(i
in 2:(N+1)) { p1[i]<-p1[i-1]*a[1] + e[i]
p2[i]<-p2[i-1]*a[2] + e[i] }
pdf("D:\\S689RC\\Fig4_4.pdf")
par(mfrow=c(1,2)) t<-0:N t1<-
paste("AR(1): a = ",a[1]) t2<-
paste("AR(1): a = ",a[2])
plot(t,p1,type='l',xlab="t",ylab="y",ma
in=t1)
plot(t,p2,type='l',xlab="t",ylab="y",ma
in=t2) dev.off()
```



ModelRisk for Insurance and Finance

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- The result of our view of the *'Frontiers of Risk Analysis':*
  - Specialized risk modeling software for *insurance and finance*
  - Over 500 risk analysis tools and functions available;
  - Works together with *any* Monte Carlo simulation tool

Fitting time-series to historical data

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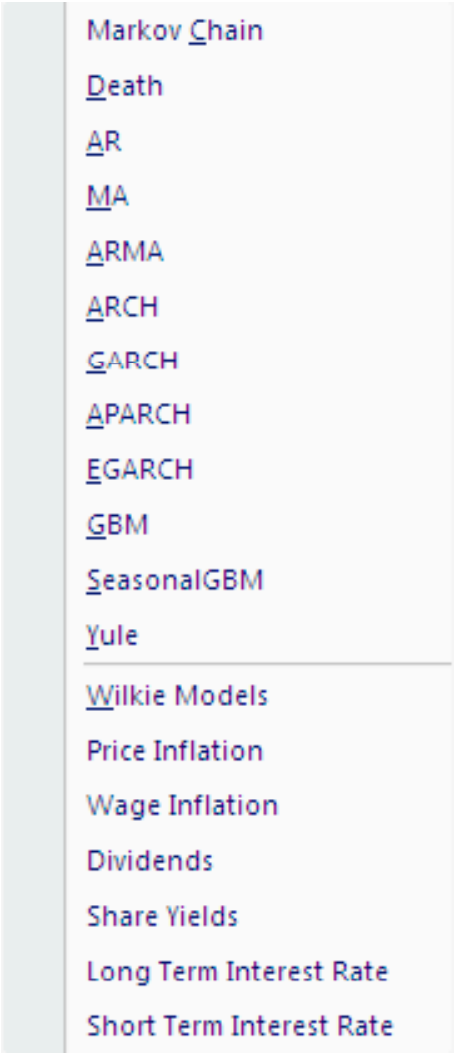
- The idea is to:
  - Determine which time-series to use
  - Estimate the parameters of the time-series
- Current most common approach:
  - Estimate parameters in statistical package;
  - Construct a model in MC simulation package
  - → Example model (exchange rate)



Time series

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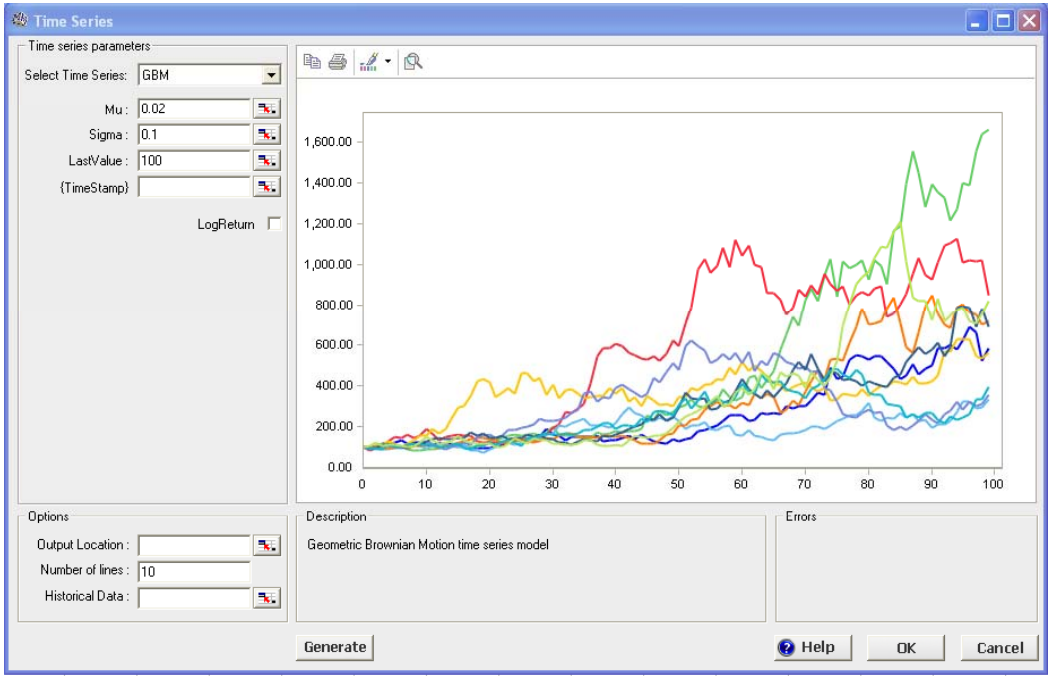
- Time Series in ModelRisk:
  - ARCH, GARCH, EGARCH, ARMA, …
  - GBM, Mean-reversion, GBMJD, Seasonal GBM, …
  - Markov Chain
  - Wilkie Models



Geometric Brownian Motion

Time Series

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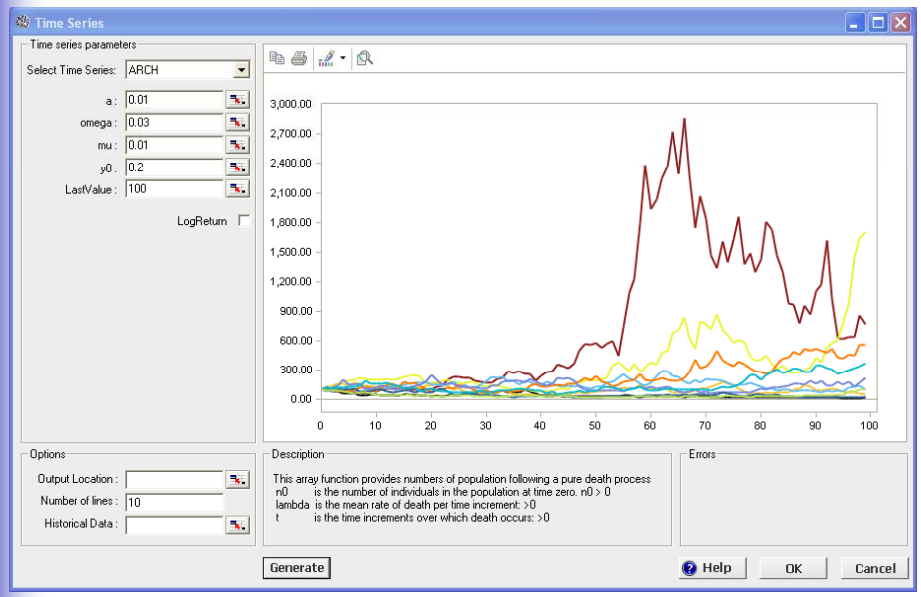
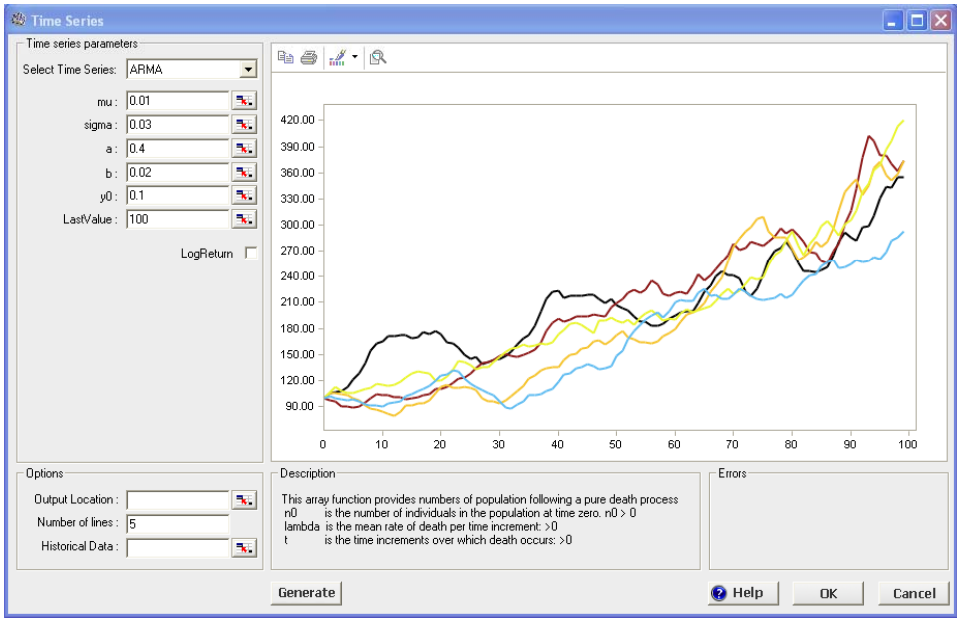


ARCH



ARMA

Time Series: Wilkie Models

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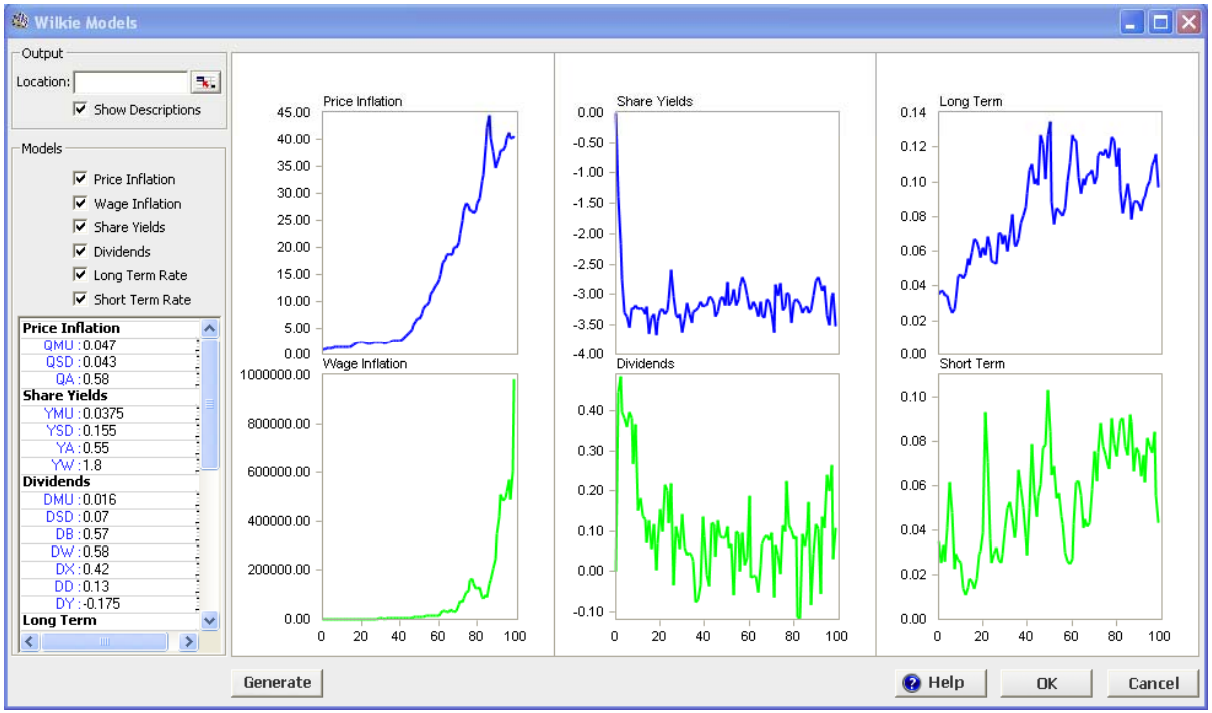
- In ModelRisk one can find the main Wilkie models: ***Price Inflation, Wage Inflation, Share Yields, Dividends, Long Term Interest Rate*** and ***Short Term Interest Rate***
- The Wilkie Models window shows you a nice overview of the selected models

Example model



Another interesting example

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- ***Credit ratings***
  - AAA, AA, C+, etc.

- **Example questions:**
  - We own a certain portfolio of bonds (with a particular credit rating). If we keep this portfolio another 1.4 years, what will the credit ratings look like?

Model

Aggregate Distributions

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- Example 1 – Insurance company:
  - Different policies
  - Each policy will have a random number of claims
  - Each claim is a random number size

- Example 2 – Bank:
  - Operational risk
  - Number of operational losses is random
  - Each operational loss has random size

Question is, what the total claim size or loss during next year?

→ Expected loss, but also 95%? 99%? 99.5%?

Aggregate Distributions

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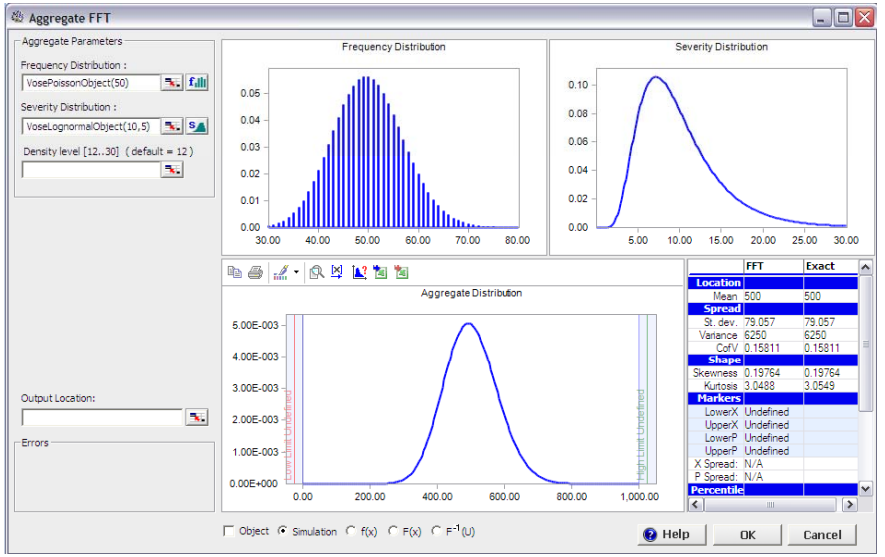
- Determining the sum of a ***random number of random sized objects*** is a very common problem in risk analysis modeling.

- Two distributions:
  - The discrete distribution representing the number of claims (or objects in general) is called Frequency Distribution and;
  - The continuous distribution representing the size of the claim (or the object) is called Severity Distribution



VoseAggregateFFT window

Aggregate Distributions

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- Aggregate methods:
  1. VoseAggregatePanjer
     - Panjer's recursive method is based on discredizing the claim size distribution
     - Only works when the claim frequency distribution is *Poisson, Geometric, Binomial, Logarithmic, Negative Binomial, Delaporte* or *Polya* (the last two are very insurance-specific and are part of ModelRisk)
  2. VoseAggregateFFT, VoseAggregateMultiFFT
     - FFT methods are more general than Panjer's. Simulations is a little slower

Aggregate Distributions

- Aggregate functions (continued):
  3. VoseAggregateMC, VoseAggregateMultiMC
     - The aggregations are performed by Monte Carlo simulation
     - Claim frequency can be a distribution or a fixed number
  4. VoseAggregateDePril
     - Individual life-insurance model

Aggregate Distributions

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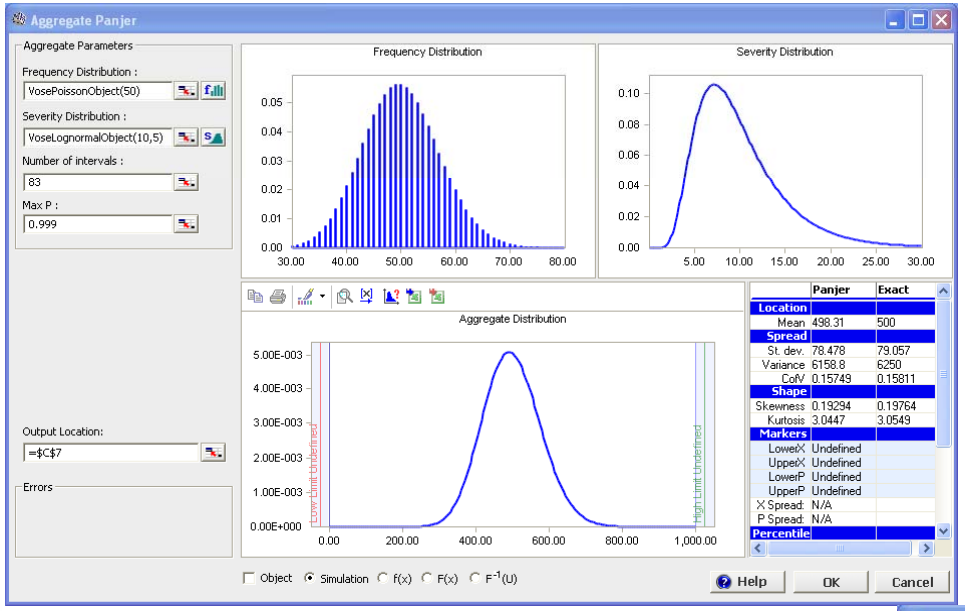
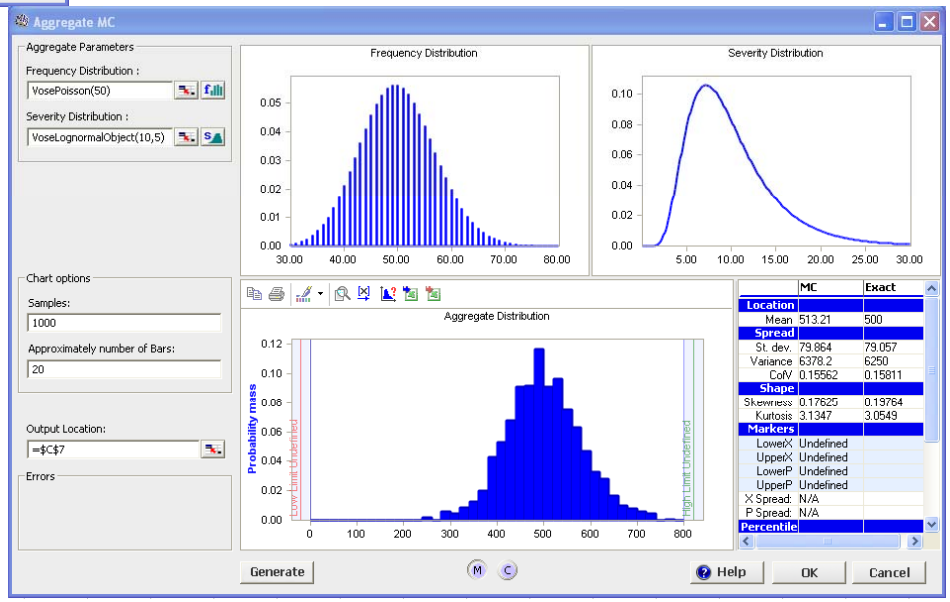


VoseAggregatePanjer window



VoseAggregateMC window

Modeling with Objects

- New way of modeling with distributions in spreadsheets
- Objects are abstract entities that help us making risk analysis model much simpler and easier to verify/review

Example model

- Finally, more education and better help (e.g. very large help-file in ModelRisk) can help risk modelers

Extreme value determinations

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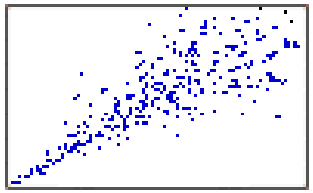
- Insurance companies (and not only they!) are often interested in better understanding extreme scenarios

  - E.g. what will be the loss of the 10 largest operational risk events?

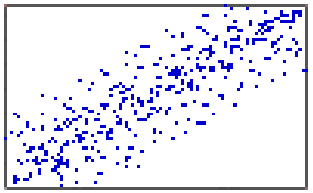
  - Or, what will be the 10 largest insurance claims

Some example models

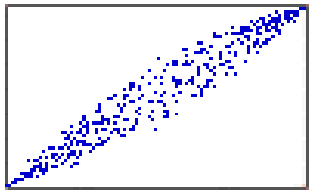
Copulas



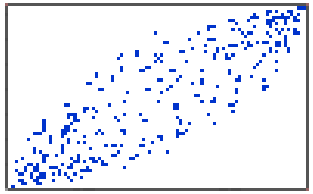
Clayton



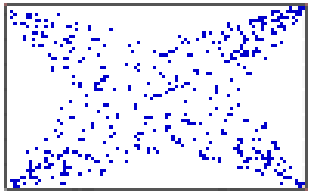
Frank



Gumbel



Normal



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Copulas

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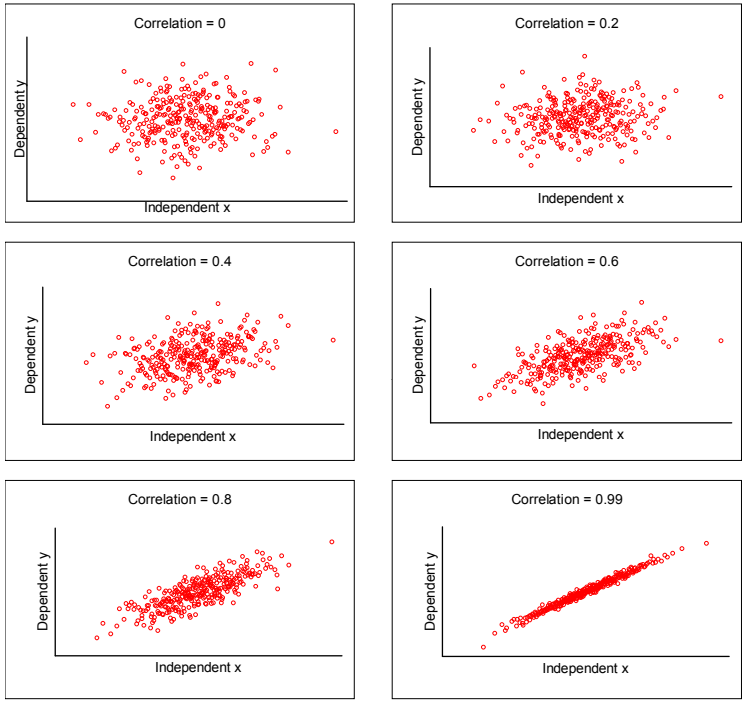

- Rank order correlation is a useful measure of dependence, but is very limited in the patterns it can produce and has no probabilistic interpretation

- Copulas offer a better method for combining marginal distributions into multivariate distributions

  Good method to capture non-linear dependency
  Greater flexibility in patterns of correlation
  Can use statistical measures to compare fits
  Unique: ModelRisk also has an empirical copula for unusual correlation patterns

Archimedean Copulas

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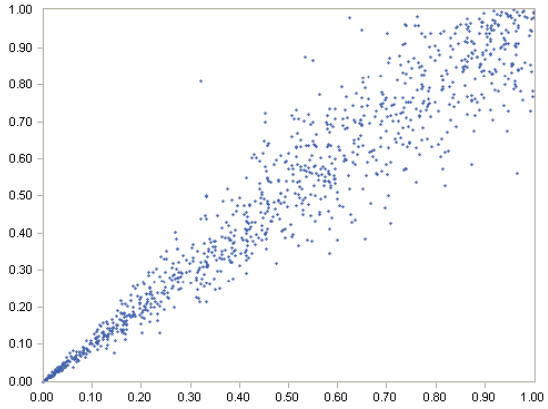
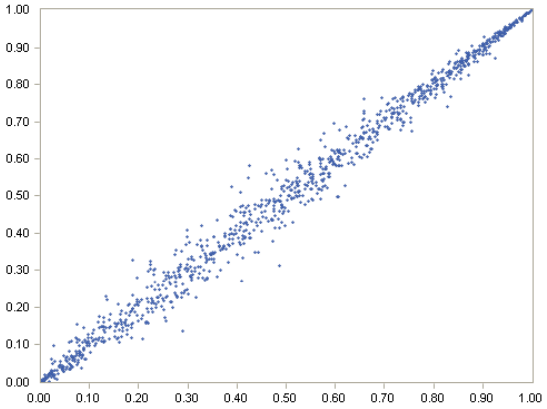
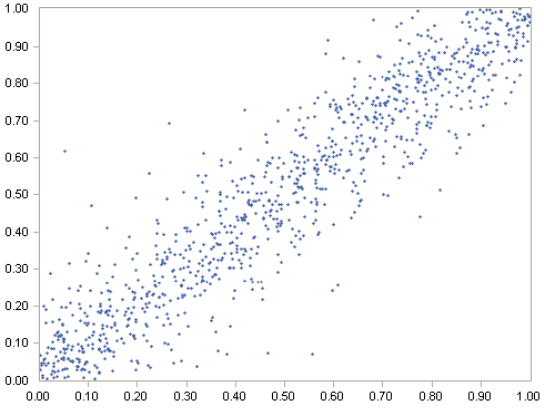


Clayton



Gumbel



Frank

Plot of two marginal distributions using 3,000 samples taken from a Clayton(10) (left), a Gumbel(15) (middle) and a Frank(15) (right) copula

Elliptical copulas

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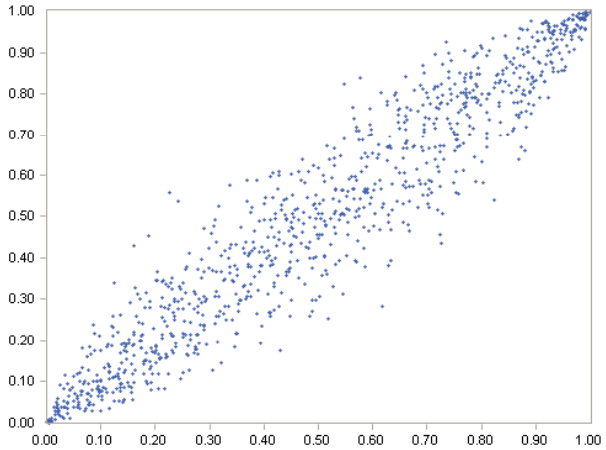
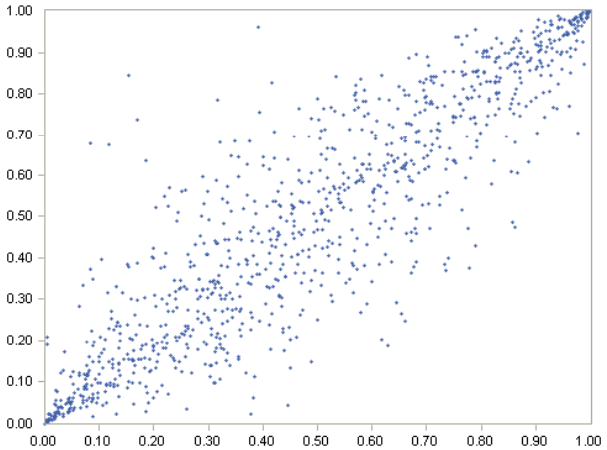
- Most common Elliptical copulas are:

Normal copula



(Student's) ***T copula***



Plot of two marginal distributions using 1000 samples taken from a Normal(0.95) (left) and a Student's T(4,0.91) (right) copula

Copulas

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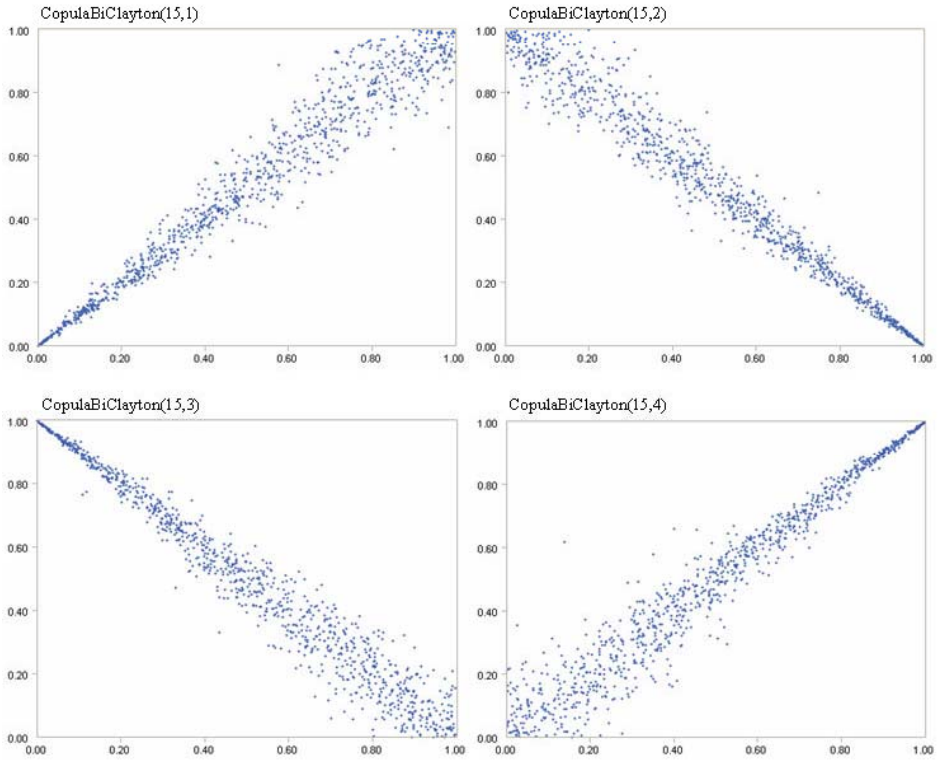
- We can use an extra parameter to allow control over the possible directional combinations for **bivariate** Archimedean copulas. The Clayton copula, for example, has four directional possibilities:



Copulas - fitting

- ModelRisk has a function that allows you to fit a copula to a set of data (just like fitting distributions or time-series).

- In the following example model, we have a data set of 1000 joint observations for each of five variables to which we will fit a *Gamma distribution* (e.g. the last five health insurance claim sizes of people) for each variable and a *Normal copula* for the correlation.

This model would make a HUGE spreadsheet without the use of ModelRisk.

Copulas – *empirical* fitting

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- ModelRisk has a function that allows you to fit an empirical copula to a set of data using order statistics theory
- In the following example model, we have a data set of 1000 joint observations for five variables exhibiting a complex correlation pattern to which we will fit empirical marginal distributions and correlate with an empirical copula.
- This method uses the least number of assumptions possible about the form of the joint and marginal distributions

Using copula's to correlate risks

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- Include a Clayton (12) Copula between the operational risk and credit risk

Risk category	Frequency	Severity (in $000)
Operational risk	=VosePoisson(35)	=VoseLognormal(20,8)
Credit risk	=VosePoisson(56)	=VoseLognormal(10,4)

Answer

ModelRisk for Insurance and Finance

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1. Specialized risk analysis tool for financial and insurance applications:

2. Over 500 tools and functions, including:
   - Time-series fitting and simulation
   - Aggregate distributions
   - Copulas to model dependency structures
   - Much more….

3. Helps the risk analyst:
   - Much faster to build your models;
   - Less prone to errors;
   - Very extensive help-file (video's, example models etc.)

Thank you!

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