Numerical software & tools for the actuarial community

John Holden

john.holden@nag.co.uk

20th March 2013

The Actuarial Profession
Staple Inn Hall

Experts in numerical algorithms
and HPC services

Agenda

- NAG Introduction
- NAG and the University of Manchester
- Numerical Software and the Insurance Market

Numerical Algorithms Group - What We Do

- NAG provides mathematical and statistical algorithm libraries widely used in industry and academia
- Established in 1970 with offices in Oxford, Manchester, Chicago, Taipei, Tokyo
- Not-for-profit organisation committed to research & development
- Library code written and contributed by some of the world's most renowned mathematicians and computer scientists
- NAG's numerical code is embedded within many vendor libraries such as AMD and Intel
- Many collaborative projects – e.g. CSE Support to the UK's largest supercomputer, HECToR

NAG and Manchester

- One of the original six founders of NAG
- Early implementers of the NAG Library based in Manchester
- NAG staff have guest positions at Manchester
  - Dr David Sayers, Dr Craig Lucas
  - Professor Sven Hammarling
- Partners in various UK and European projects
  - For Stochastic ODEs, Nearest Correlation Matrix, Matrix functions
  - Linear Algebra (with Jack Dongarra as visiting Professor!)
  - For HPCFinance.eu
- Student prizes and projects with
  - Applied Numerical Computing, Mathematical Finance & Actuarial Science

Software providers to the Insurance Market

- ACTUARIS
- AIR Worldwide
- Algorithmics
- Aon Benfield
- ARC
- AXIS
- Barrie & Hibbert
- BPS Resolver
- BWise
- ClusterSeven
- Conducter
- Conning
- …
- …
- ..
- Microsoft
- The Numerical Algorithms Group (NAG)
- Oracle Financial Services
- PolySytems
- P-Solve
- RMS
- SAS Institute
- SunGard
- Towers Watson
- Trillium Software
- Ultimate Risk Solutions
- WySTAR

How is this software made?

- Do these software providers write all their own code?
- Do these software providers write all their own Numerical Code?
- Why not?

How is this software made?

- Do these software providers write all their own code?

  No

- Do these software providers write all their own Numerical Code?

  No

- Why not?

  Let's take a look

Good numerical software is difficult to write

- Problems of
  - Overflow / underflow
    - How does the computation behave for large / small numbers?
  - Condition
    - How is it affected by small changes in the input?
  - Stability
    - How sensitive is the computation to rounding errors?
- Importance of
    - error analysis
    - information about error bounds on solution

An example: sample variance

- For a collection of observations

$$\{x_i, i = 1 \ldots n\}$$

the mean is defined as

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

and the variance as

$$s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2$$

Example calculation

- For this collection of observations

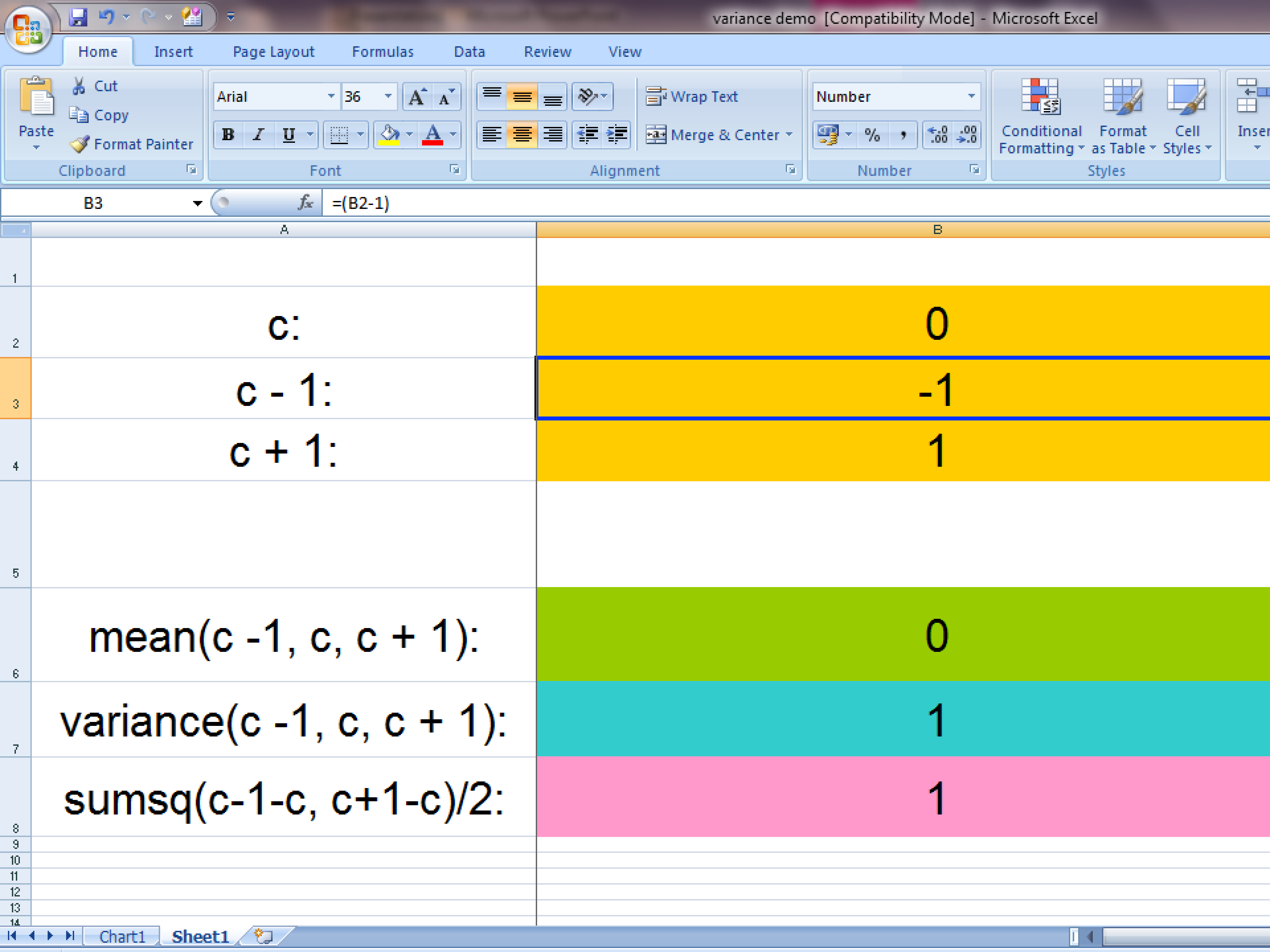
$$\{c-1, c, c+1\}$$

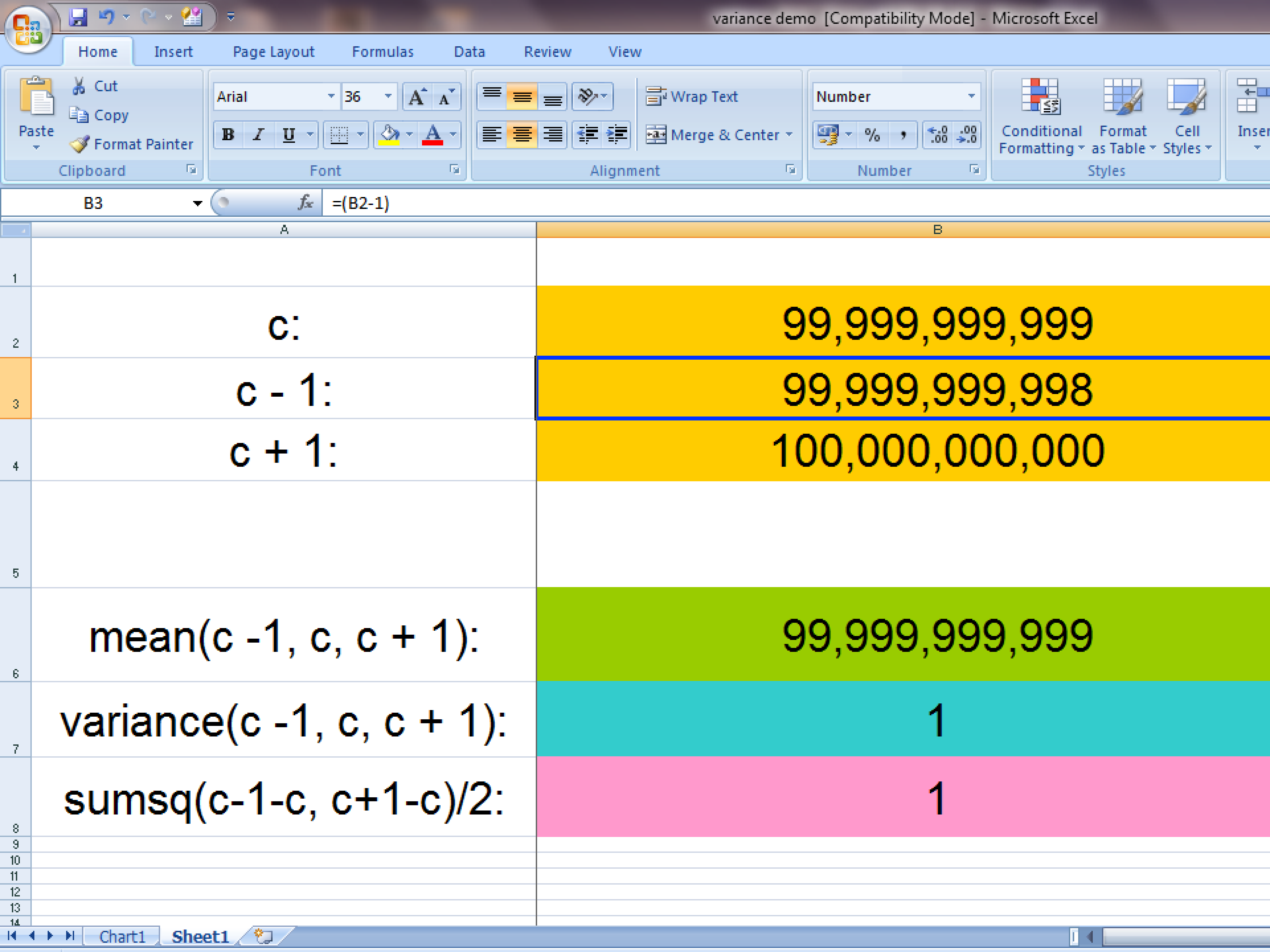
the mean is

$$\bar{x} = \frac{1}{3}(c-1+c+c+1) = c$$

and the variance is

$$s^2 = \frac{1}{2}((-1)^2 + 0 + 1^2) = 1$$


variance demo [Compatibility Mode] - Microsoft Excel
Home
Insert
Page Layout
Formulas
Data
Review
View
Cut
Copy
Format Painter
Paste
Clipboard
Arial
36
Font
Wrap Text
Merge & Center
Alignment
Number
Number
Conditional Formatting
Format as Table
Cell Styles
Styles
B3
=(B2-1)
c:
0
c - 1:
-1
c + 1:
1
mean(c -1, c, c + 1):
0
variance(c -1, c, c + 1):
1
sumsq(c-1-c, c+1-c)/2:
1
Chart1
Sheet1



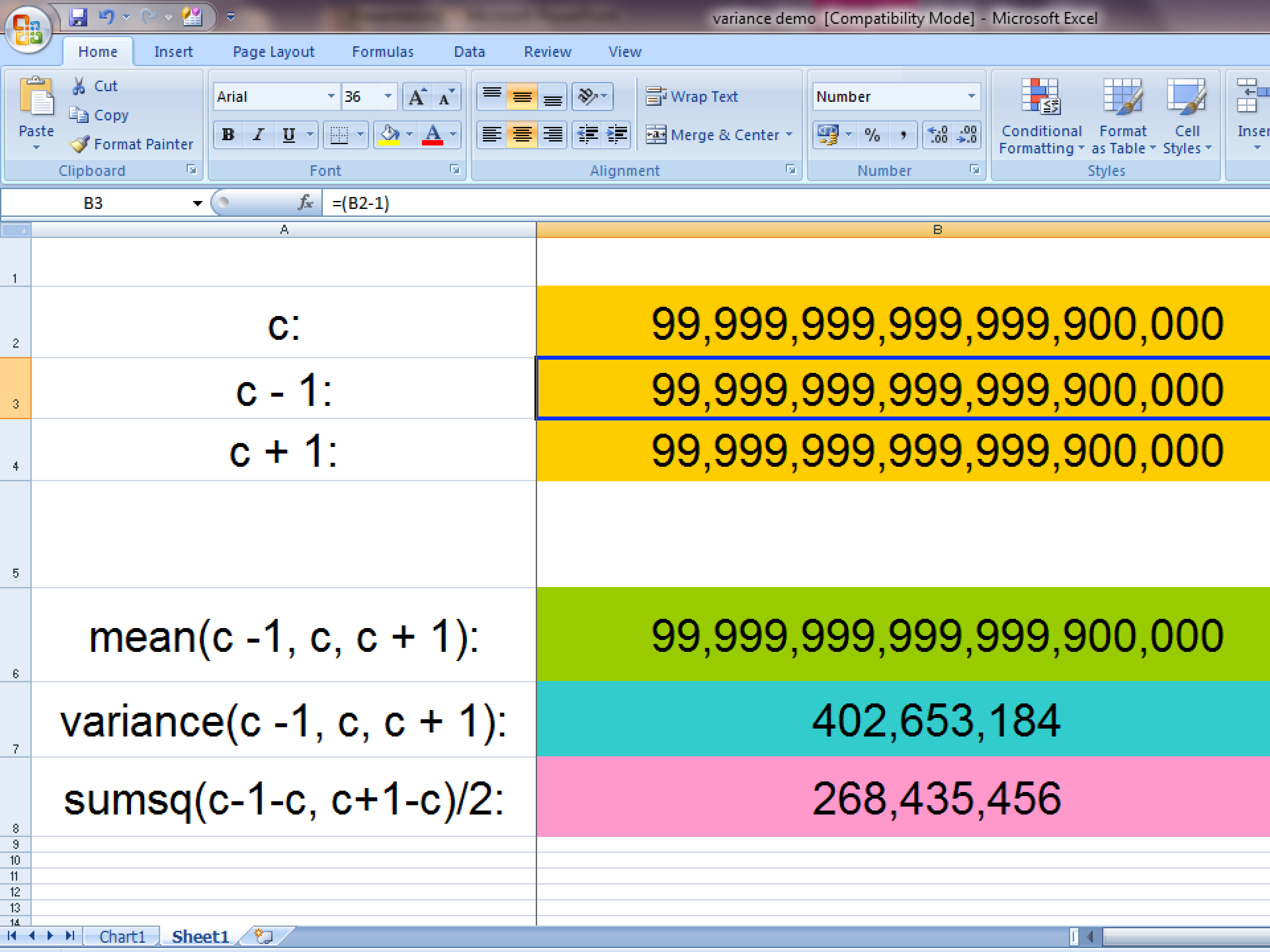
variance demo [Compatibility Mode] - Microsoft Excel
Home
Insert
Page Layout
Formulas
Data
Review
View
Paste
Cut
Copy
Format Painter
Clipboard
Arial
36
Font
Wrap Text
Merge & Center
Alignment
Number
Conditional Formatting
Format as Table
Cell Styles
Styles
B3
=(B2-1)
c:
99,999,999,999
c - 1:
99,999,999,998
c + 1:
100,000,000,000
mean(c -1, c, c + 1):
99,999,999,999
variance(c -1, c, c + 1):
1
sumsq(c-1-c, c+1-c)/2:
1
Chart1
Sheet1

variance demo [Compatibility Mode] - Microsoft Excel

B3 =(B2-1)

	A	B
1		
2	c:	9,999,999,999,999,990,000
3	c - 1:	9,999,999,999,999,990,000
4	c + 1:	9,999,999,999,999,990,000
5		
6	mean(c -1, c, c + 1):	9,999,999,999,999,990,000
7	variance(c -1, c, c + 1):	18,889,465,931,478,600,000,000
8	sumsq(c-1-c, c+1-c)/2:	0

Chart1 Sheet1



	A	B
1		
2	c:	99,999,999,999,999,900,000
3	c - 1:	99,999,999,999,999,900,000
4	c + 1:	99,999,999,999,999,900,000
5		
6	mean(c -1, c, c + 1):	99,999,999,999,999,900,000
7	variance(c -1, c, c + 1):	402,653,184
8	sumsq(c-1-c, c+1-c)/2:	268,435,456

What’s gone wrong?

- Professor Higham will explain in his talk

Numerical computation – DIY Vs NAG

- DIY implementations of numerical components have their place, but NOT in production code.
  - Handwritten and "hand me down" type code might be easy to implement, but will…
    - NOT be well tested
    - NOT fast
    - NOT **stable**
    - NOT deliver good error handling
  - NAG implementations in contrast are **fast** and
    - Accurate, Well tested
    - Updated
    - Thoroughly documented
    - Give "qualified error" messages e.g. tolerances of answers (which the user can choose to ignore, but avoids proceeding blindly)

Software providers to the Insurance Market

- ACTUARIS
- AIR Worldwide
- Algorithmics
- Aon Benfield
- ARC
- AXIS
- Barrie & Hibbert
- BPS Resolver
- BWise
- ClusterSeven
- Conducter
- Conning
- …
- …
- ..
- Microsoft
- The Numerical Algorithms Group (NAG)
- Oracle Financial Services
- PolySytems
- P-Solve
- RMS
- SAS Institute
- SunGard
- Towers Watson
- Trillium Software
- Ultimate Risk Solutions
- WySTAR

NAG Library and Toolbox Contents

- Root Finding
- Summation of Series
- Quadrature
- Ordinary Differential Equations
- Partial Differential Equations
- Numerical Differentiation
- Integral Equations
- Mesh Generation
- Interpolation
- Curve and Surface Fitting
- Optimization
- Approximations of Special Functions
- Dense Linear Algebra
- Sparse Linear Algebra
- Correlation & Regression Analysis
- Multivariate Methods
- Analysis of Variance
- Random Number Generators
- Univariate Estimation
- Nonparametric Statistics
- Smoothing in Statistics
- Contingency Table Analysis
- Survival Analysis
- Time Series Analysis
- Operations Research

The NAG Library and Actuarial Statistics

- Survival models:
    - Cox regression model (g12bac)
    - Kaplan-Meier estimator (g12aac)
    - Weibull, exponential and extreme values (via g01gcc)
- Risk analysis/ loss functions:
  - Distributions:
    - lognormal, gamma, beta etc both distribution functions (g01) & random number generation (g05).
- Other
  - Time series (g05 and g13)
  - Convolutions: FFT's (c06)
  - Kernel density estimation
  - Graduation: generalised linear models (g02g)
  - Analysis of risk factors: Generalised Linear Models (g02g)

Use of NAG Software in Finance

- Portfolio analysis / Index tracking / Risk management
  - Optimization , linear algebra, copulas…
- Derivative pricing
  - PDEs, RNGs, multivariate normal, …
- Fixed Income/ Asset management / Portfolio Immunization
  - Operations research
- Data analysis
  - Time series, GARCH, principal component analysis, data smoothing,
- Monte Carlo simulation
  - RNGs, PCA, Brownian Bridge
- Extreme Value Theory modelling
  - EVT solvers, Copulas

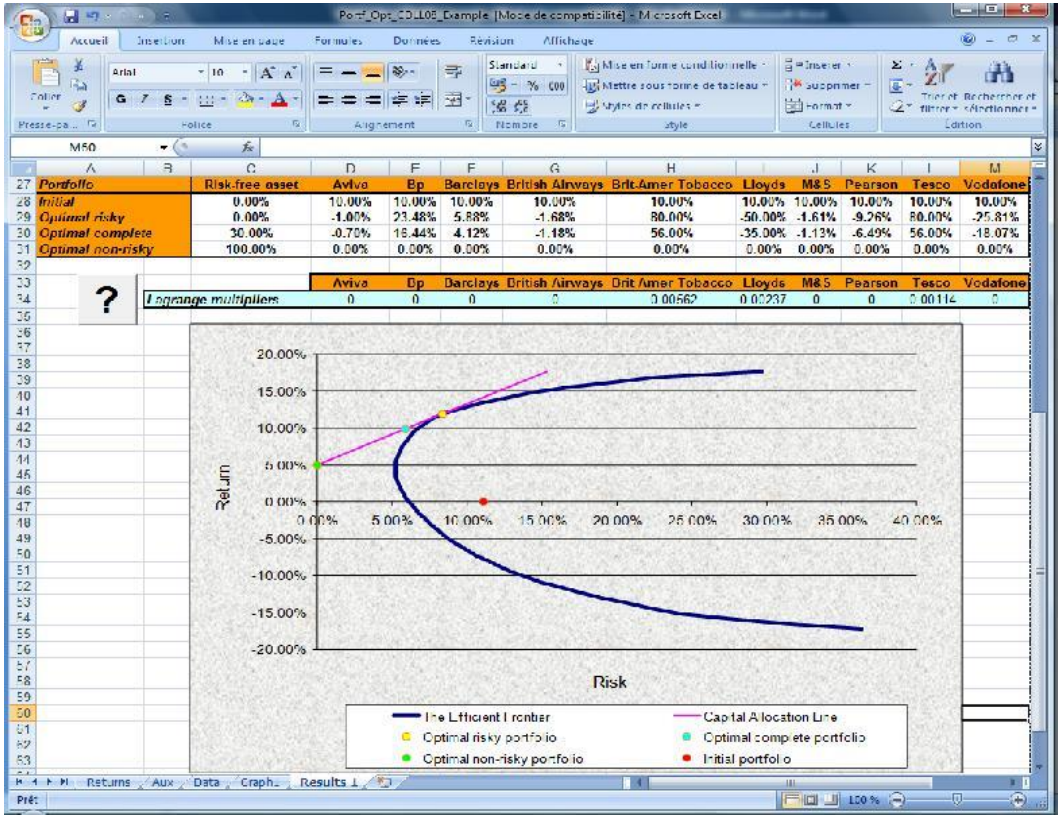
NAG fits into your favourite environments

- Supporting Wide Range of Operating systems…
  - Windows, Linux, Solaris, Mac, …
- …and a number of interfaces
  - C, C++
  - Fortran
  - VB, VBA
  - C#, F#, VB.NET
  - CUDA, OpenCL
  - Java
  - Python
  - …
  - Excel
  - LabVIEW
  - MATLAB
  - Maple
  - Mathematica
  - R, S-Plus
  - Scilab, Octave
  - …

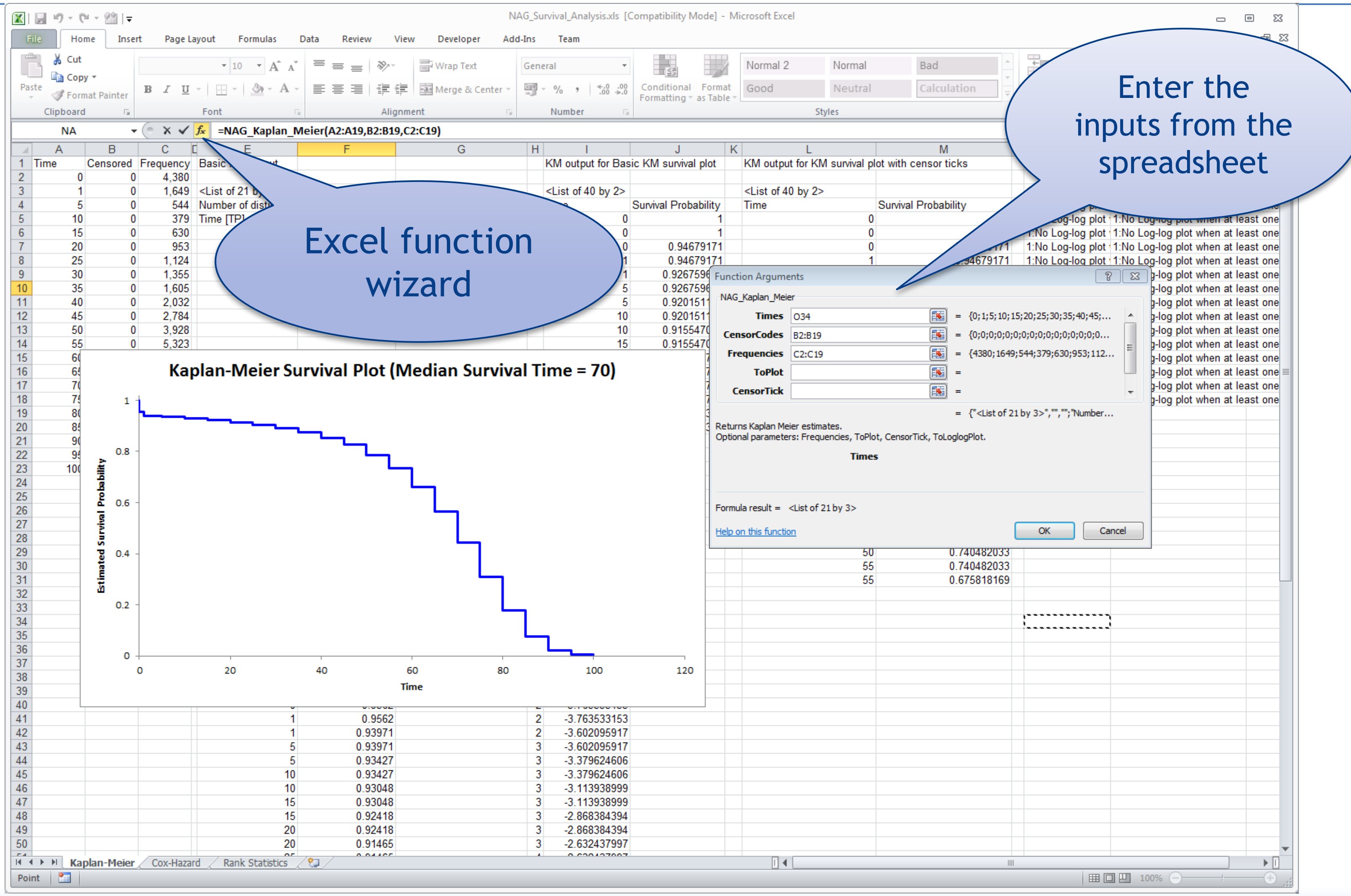
NAG and Excel

Our libraries are easily accessible from Excel:

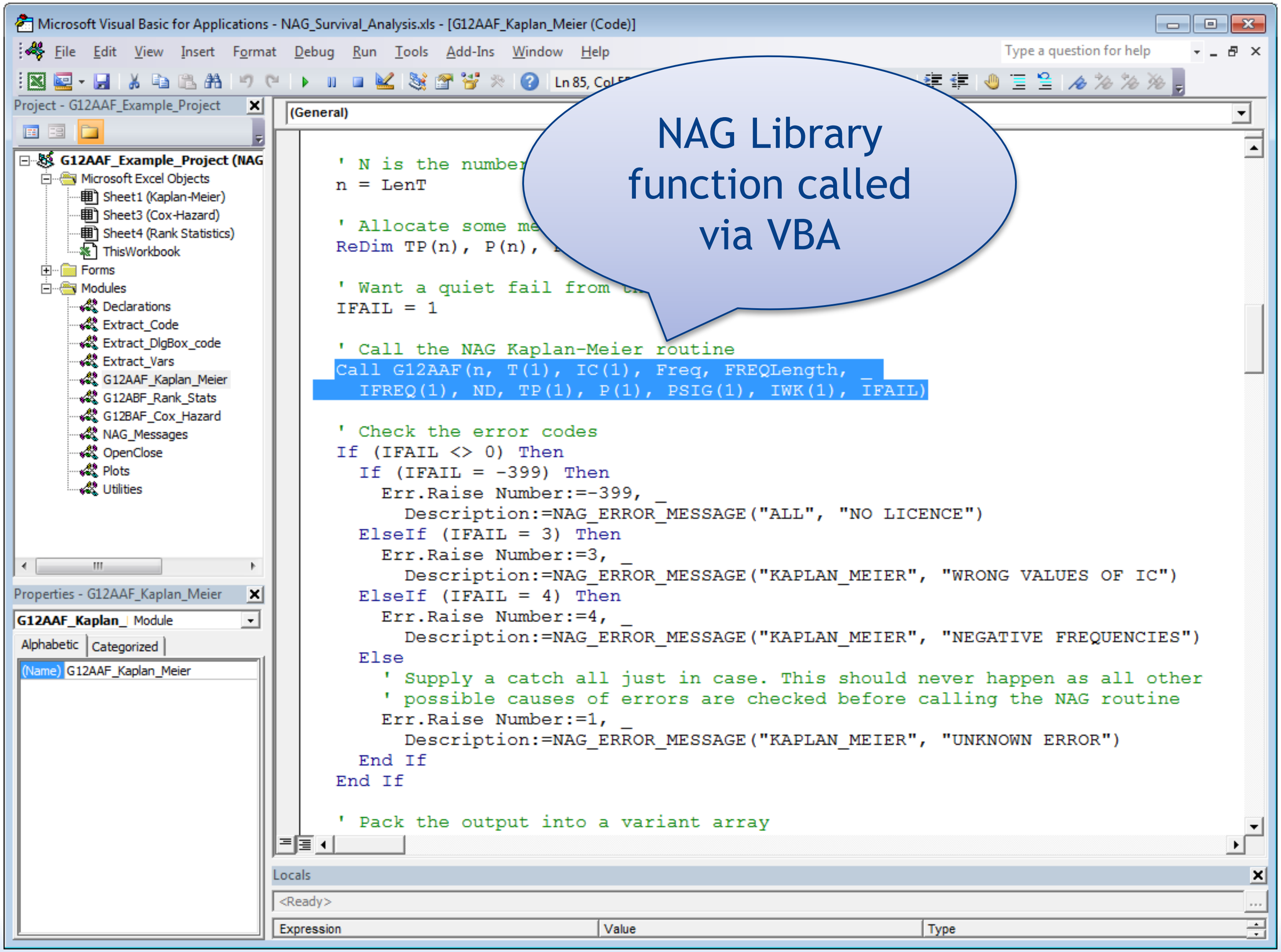
- Calling **NAG DLLs** using VBA
  - NAG provide VB Declaration Statements and Examples
  - NAG provide “Add-ins”
- Calling **NAG Library for .NET** using VSTO
- Functions with Reverse Communication (useful for Solver replication for example) can be provided
- Create NAG XLLs



How do you call NAG functions in Excel



What's under the hood?



Recent examples of work

- Fitting a variance gamma distribution to some observed data (using solvers from the NAG Library, VBA & Excel)
- In a another example, the customer did not have access to the full dataset, but rather they had a series of quantiles and wished to know which EGB2 distribution best described these quantiles. NAG gave advice on how to fit an EGB2 distribution to the quantiles and hence estimate the parameters of the distribution.

NAG and Actuarial Science - Summary

- NAG is keen to collaborate in building actuarial models and risk engines
  - Your requirements likely to be different from banks/hedge funds
  - We want to make sure we have what you need
- Risk engines likely to involve a LOT of computation
  - NAG has *significant* experience in HPC services, consulting and training
  - We know how to do large scale computations efficiently
  - *This is non-trivial*! Our expertise has been sought out and exploited by organisations such as (BP, HECToR, Microsoft, Oracle, Rolls Royce, …….)