Recent developments from NAG

NAG / Wilmott Quant Event
22nd October 2009

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nag®

Experts in numerical algorithms and HPC services

Agenda

- NAG Library and latest releases
  - New Functionality
  - NAG Toolbox for MATLAB version
  - Easily called into Excel
- NAG and .NET
- NAG Numerical Routines for GPUs

New Functionality

- Global optimization
- ANOVA – Analysis of Variance
- Nearest Correlation Matrix
- Partial Least Squares Regression Analysis
- Prediction intervals for fitted models
- Option Pricing
- Additional Copulas
- Extreme Value Theory Stats
- Fast quantile selection routine
- Generalised Mixed Effect Regression
- Wavelets
- Adoption of LAPACK 3.1
- New RNGs
  - Scrambled Seq for QMC
  - Mersenne Twister
  - Sobol Sequence generator (50,000 dimensions)

Nearest correlation matrix

- Based on a method by Qi and Sun, with improvements suggested by Higham and Borsdorf.

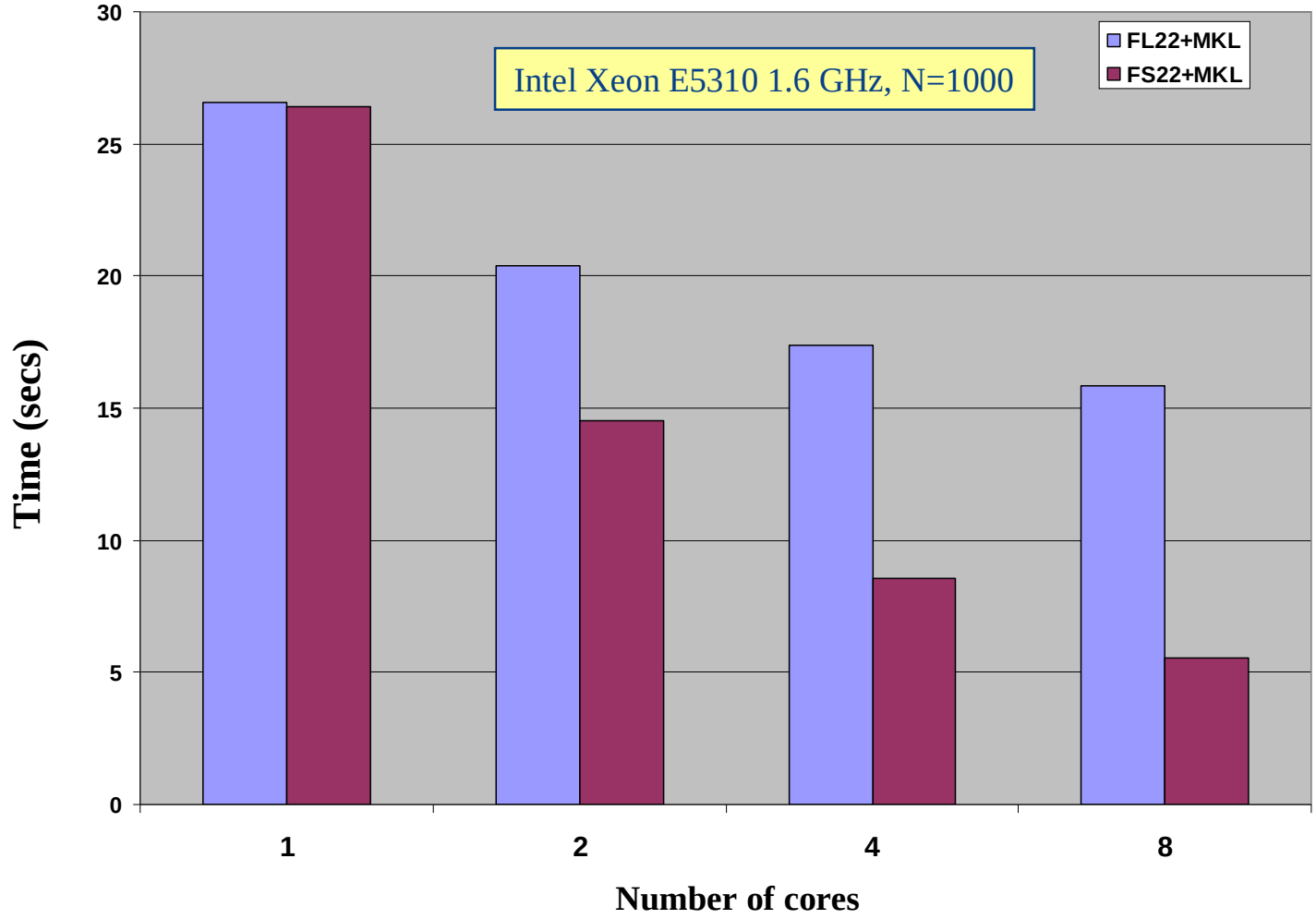
- NAG routine minimises the Frobenius norm of the difference between the original matrix and the correlation matrix.

Nearest correlation matrix

One of the features of this algorithm is that large matrices may be handled. As extensive use is made of BLAS routines we can exploit the optimized BLAS libraries available on many machines.

The algorithm thus lends itself well to exploitation of the machine architecture in both our serial and SMP implementations.

Multi-Core example
Nearest-correlation matrix (NCM)



Global Optimization

- A suite of routines to find the global minimum of a general function subject to simple bound constraints.
- The method used is Multilevel Coordinate Search
- Use a systematic means of searching the feasible area. Has already been used in earnest:

http://www.nag.co.uk/IndustryArticles/OptimizingOmegaPaper.pdf

Option Pricing Functions

- Closed form solutions with Greeks which provide a reference framework for approximate numerical methods: Monte Carlo, PDE, Trees
  - Written initially for the academic audience i.e. to aid the teaching of financial mathematics*

**we are now told by some of you that there will be circumstances where these functions are useful for the real practitioner!*

Why use closed form solutions?

- Fast
- Easy to calibrate
- Robust
- Accurate (in terms of mathematical model)

But

- Only exist for some options
- Lack the flexibility of simulation

Option Pricing Functions

European options:

- Black-Scholes-Merton
- Lookback – Floating-Strike
- Binary
  - Cash-or-Nothing
  - Asset-or-Nothing
- Barrier – Standard
- Jump-diffusion – Merton Model
- Heston's Stochastic Volatility Model

American option:

- Bjerksund & Stensland (2002) approximation

Asian option:

- Geometric Continuous Average-Rate

Wavelets

Market Intervention/Manipulation

Are market prices influenced by large players – hedge funds, …?

June 2007 – New Zealand government attempted to reverse rise in NZD by injecting large sums into FX markets.

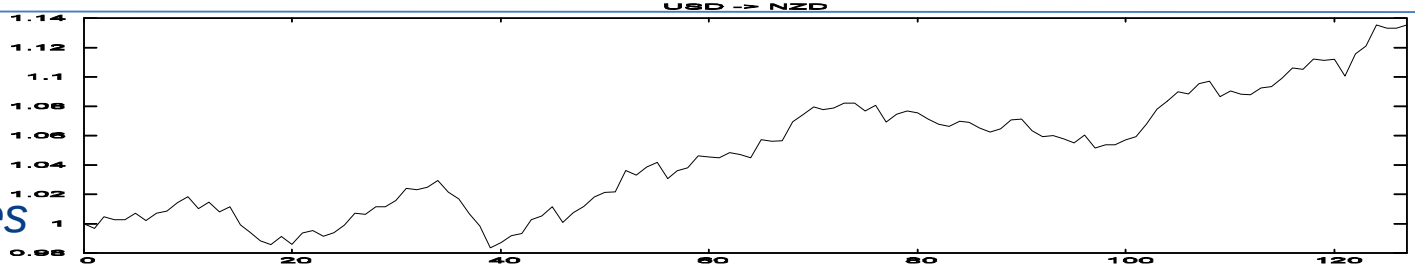
Wavelet analysis of time series of spot prices shows result …

USD-NZD, Haar MODWT (end effects removed) – NZ govt intervention towards end (right)

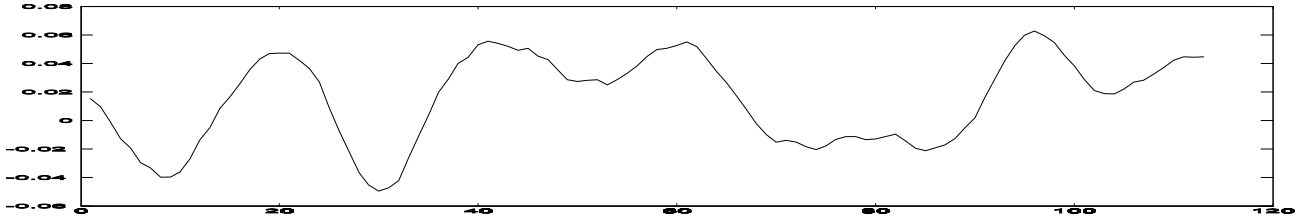
x(t)

spot

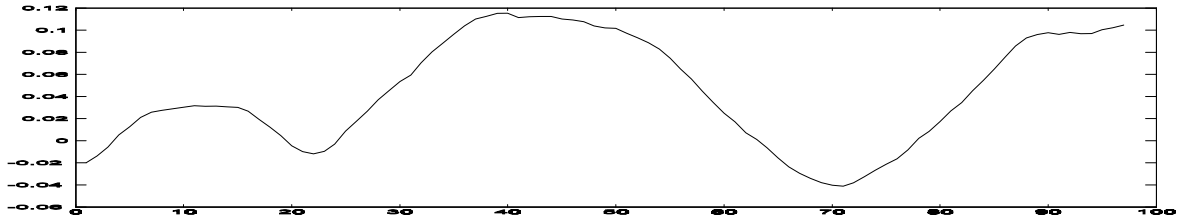
prices



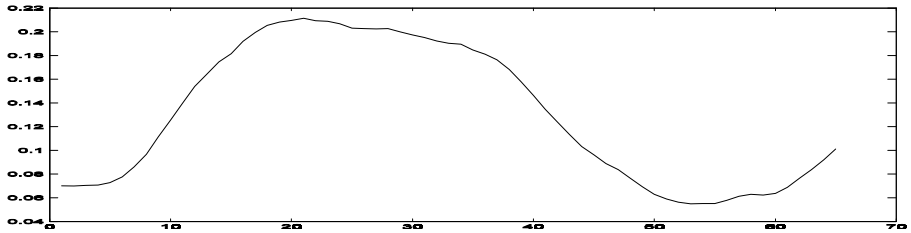
d4



d5

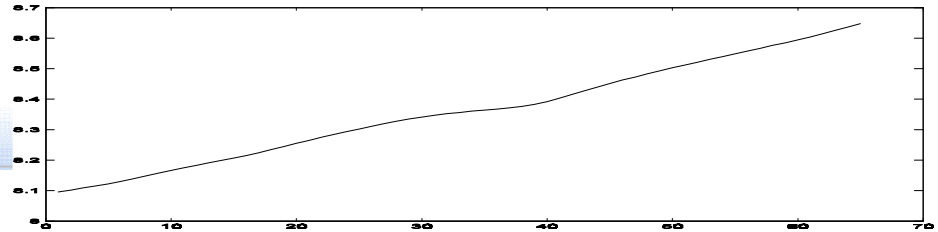


d6



s6

smooth coeffs – trend

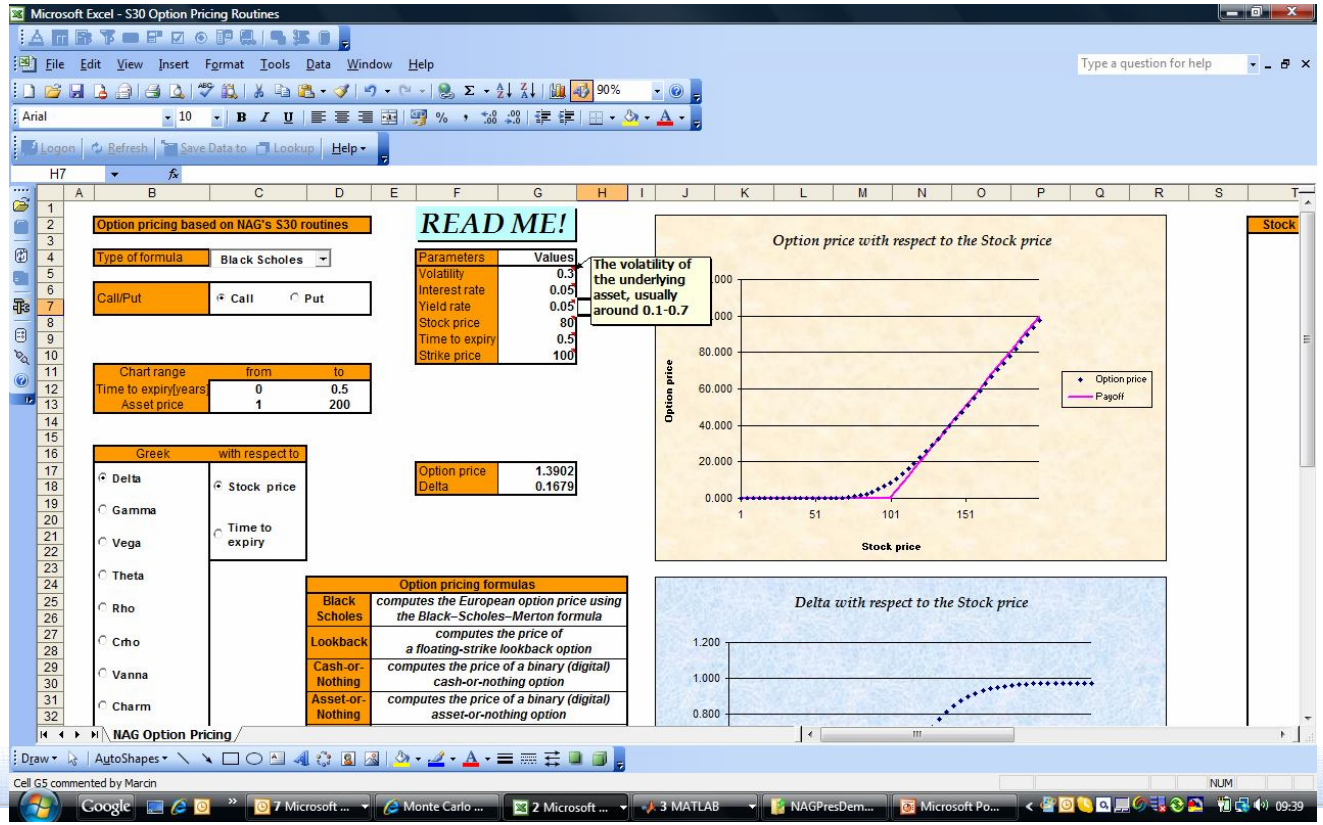


Wavelet Transforms (1D)

- Wavelet filter query
- Discrete wavelet transform in 1D (DWT)
- Inverse discrete wavelet transform in 1D (IDWT)
- Multi-level discrete wavelet transform in 1D (MLDWT)
- Inverse multi-level discrete wavelet transform in 1D (IMLDWT)

NAG and Excel..

- **Our libraries are easily accessible from Excel**
  - Calling DLLs using VBA
  - NAG provide VB Declaration Statements and Examples



NAG Toolbox for MATLAB

- Contains essentially all NAG functionality
  - not a subset
- Runs under Windows (32/64bit) and Linux (32/64-bit).
- Installed by default under the usual MATLAB toolbox directory
- Can be used with MATLAB compiler

NAG and .NET

- Current Solutions
- Timings
- Next Release
- Roadmap

NAG and .NET

NAG solutions for .NET

1. **Call NAG C (or Fortran) DLL from C#**

2. NAG Library for .NET (beta 1)

   "a more natural solution"

   - DLL with C# wrappers
   - Integrated help

3. NAG Library for .NET (Work-in-Progress)

   - as above pure C# functions

NAG Library for .NET – beta 1

Two main components

1. .NET managed assembly
   - set of classes with static methods
2. NAG DLL

Also supplied

- Examples of Use
  - All functions come with examples
- Fully Integrated Help with Visual Studio
  - Including Intellisense

NAG Library for .NET - Timings

DLL Vs Pure .NET Code Timings

- DGEMM (matrix matrix multiply 50,000 x 5)
  - DLL – 297ms
  - Pure .NET – 953 ms
- Quadrature (2,000 solutions with call-back)
  - DLL – 798ms
  - Pure .NET – 316ms

NAG Library for .NET - Next Beta Release

Due November 2009

- Quadrature (d01)
- Statistics
- Simple Stats (g01)
- Regression (g02)
- RNGs and distributions (g05)
- Time Series Analysis (g13)

NAG Library for .NET - Road Map

- Curve and Surface Fitting
- Linear Algebra
- Statistics
- ..
- ..
- ***You can help set the priorities***

- ***Pure .NET and DLL solutions***
- Aim to incorporate the full NAG Library

NAG and GPUs

- Current offering
- User quotes
- Next steps

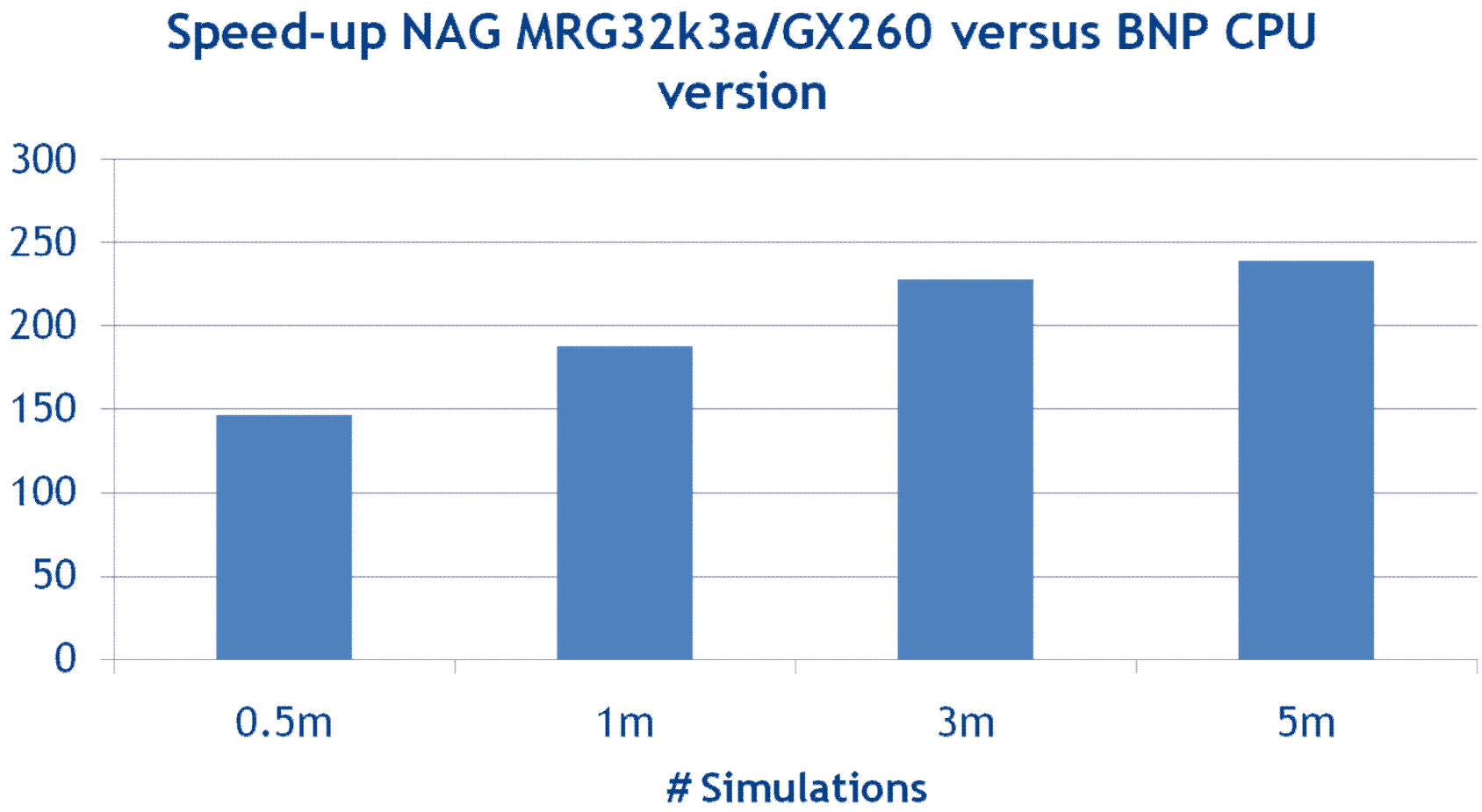
NAG Numerical Routines for GPUs

- Currently in beta, but pressure to productise
- Currently a few RNGs and distributions and Brownian Bridge
  - Available as a beta release

Early Success with BNP Paribas

- Working with Fixed Income Research & Strategies Team (FIRST)
  - NAG mrg32k3a works well in BNP Paribas CUDA “Local Vol Monte-Carlo”
  - Passes “tests of randomness”
    [Double Precision - version passes TestU01]
  - Performance good (next slide)
  - Being able to match the GPU random numbers with the CPU version of mrg32k3a has been very valuable for debugging purposes

BNP Paribas Results



And with Merrill Lynch (BoA)

"The NAG GPU libraries are helping us enormously by providing us with fast, good quality algorithms. This has let us concentrate on our models and deliver GPGPU based pricing much more quickly."

- Matt Leslie, Equity Linked Analytics Group, Merrill Lynch

NAG Numerical Routines for GPUs

- Which other algorithms do we need to implement?
  - Copulas, Linear Algebra, Optimization, PDEs, Wavelets,... ?

NAG Numerical Routines for GPUs

Acknowledgements

We would like to thank the Technology Strategy Board (TSB) and the Smith Institute for their support in sponsoring this project and EPSRC for supporting Professor Mike Giles' academic research

Summary

- NAG for Quality, World-leading Numerical Software Components
  - accurate, reliable, robust
  - extensively tested, supported and maintained code
  - updated for new architectures and new algorithms

Further Information

NAG Libraries
www.nag.co.uk/numeric/numerical_libraries.asp

NAG Toolbox for MATLAB
www.nag.co.uk/numeric/MB/start.asp

NAG and Excel www.nag.co.uk/numeric/nagandexcel.asp

NAG and .NET www.nag.co.uk/microsoft_dotnet.asp

NAG and GPUs www.nag.co.uk/numeric/GPUs/