

Economics programs written in *Mathematica*

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Summary

The program *Mathematica* is being discovered by economists. This paper introduces a number of programs that help to provide a working and teaching environment. Keywords are: Chi2, CrossTable, Decision, Dbase, DifData, Finance, Graphics, Inference, Logic, Minimax, Modeling, Sampling, Statistics, Calculus, CES, Economic`Common, Economic`Optimise, IADS, Lagrange, LevelCES, Applied General Equilibrium Analysis, Neural Networks, Nonlinear Estimate, Leontief, List, Manager, Matrices, Tool, Chain Indices, Declare, Genetic Programming.

Introduction

It seems to me that *Mathematica* may be one of the revolutions of mankind. It lists with the invention of the wheel, the alphabet, hygiene, the steam engine, women's lib, ... What penicilline is to an infected person, what Adam Smith's *Wealth of Nations* means for civilisation, is what *Mathematica* will likely be to human inquiry ... Well, perhaps put too dramatically, but, it may get the message across.

Generations of mathematical geniusses have been designing an elegant and compact language to state their theorems and proofs: mathematics. This language is now being implemented on the computer. By consequence, there is a much easier and faster interface between mind and machine. The best way to see what this actually means, is to use *Mathematica*.

These present notebooks and packages have been developed for economics. I'm econometrician involved in decision support, and these tools have served and still serve their purpose. Also, I like to have my software neat and well documented. My conjecture is that others could use it too.

These applications may help others:

- to get the job done
- to get a feel of *Mathematica*
- to get a feel of the discussed problems
- to have fun
- or, to create higher level complexity.

Keywords on ...

Applied General Equilibrium Analysis

Extend on Asahi Noguchi's packages, see Varian (1993).¹

Solve systems of production and utility functions and plot 2D diagrams for arbitrary sectors and factors. Plot their time trajectories.

Have easy access to the (Dynamic) Leontief Model.

Calculus

Substitute $y = f[x]$ back into $D[y, x]$ to get a simpler expression.

A general routine to use Lagrange multipliers.

Decision Making

Logic and inference.

Statistical decision theory including game theory (e.g. minimax).

Crosstables, and ChiSquare tests (in higher dimensions).

Data

Database, datafiles, using packages as datafiles, data contexts, data dictionary

Econometrics

Use NonlinearFit for estimation of equations and systems of equations, with an estimated variance for the estimated parameters.

Errors in variables for one equation.

Lags, Arima and some tests of the WRI Time Series Pack.

Economics

Some general efficiency, minimal cost, maximal profit, and factor demand routines.

Applications on the CES, LevelCES and IADS functions, while providing the proper limits for Leontief, Cobb-Douglas and Line functions.

Standard representation of factors, price, coefficients and key parameters. Write your own function using the standard, and call the general routines.

¹ I gratefully acknowledge Asahi Noguchi's comment: "... you have done a great deal of elaboration onto former works of mine and others. I am very pleased to see it, and convinced that it will be a useful tool for anyone doing economics using *Mathematica*."

Economics Papers

A solution approach to problems of unemployment and inflation, using *Mathematica* as a word processor, while including many graphs created with it.

Using Dutch data of 1950-1995 for a further explanation of the analysis on unemployment. Provide your own data and test the analysis for your own country.

See how you might apply Chi2 tests to Frauds in the European Community.

Let the gasoline price at the center of a metropolitan area be higher than in the surrounding rural area.

Finance

Flat rates & basics.

Try the WRI Finance Package and use some additional features.

Genetic Programming

Define a population, a fitness criterion, and evolve.²

Graphics

Plans, events, bond durations, calendar dates.

Use arrow diagrams to clarify relations between variables.

² My package was inspired by a notebook by Kleid (1994). Unfortunately, Kleid's electronic address was not functioning in 1995, so I found myself unable to discuss with him the possibility of simply copying some of his routines; and thus I have written my own. This appeared to be feasible in a relatively short time due to the properties of *Mathematica*, particularly of its internal administration of parts and levels within functions. (That property is also exploited in my package on the "Level CES function".)

I found that the problem of genetic programming very much dictates the programming structure:

- (a) an initial population,
- (b) scoring on a criterion,
- (c) breeding,
- (d) iterate.

I noted errors in Kleid's notebook, on crossover, his "doCheck" subroutine, and fitness selection. And, since I was inspired by Kleid's notebook myself, I like to point out the features of my own programming:

- (a) the genetic engine is put into package instead of a notebook: with quicker loading, better balance between front and background, and always available "?" help,
- (b) embedding in \$Cool and standard *Mathematica* packages,
- (c) exploit of the *Mathematica* programming language, better building blocks, and transparent code for whom who needs to adapt,
- (d) flexible input/output e.g. by use of options,
- (e) use of constants and functions with more arguments,
- (f) natural names like Genesis, Birth, etc.,
- (g) features like Evolve, Seed, Method, Death, Mutate, FlexibleSize, Duration,
- (h) least squares estimation as the key example rather than centering a cart,
- (i) use of packages for (separate) Fitness routines, see for example the Cool`GP`Estimation`, Cool`GP`Cart` packages,
- (j) wider range for mutations since also the head of expressions may change (and this is no problem since I always keep the fittest in the population).

Linear Algebra

Create block diagonal matrices (used in estimation, of course).

Modeling

Make a model with various lags, and simulate it for a period. Store the various runs, and compare the outcomes.

Neural Networks

Use a "master" packages for Freeman's packages, see Freeman (1994).

Statistics

See Decision Making.

Chain indices. Using approximate US data as an example.

System Enhancement

Speed up the loading of common routines, and use separate contexts: Common, Declare, Graphics, List, Manager and Tool.

Have various packages share common keywords with AddedUsage, store and reset definitions without saving, inspect and show levels and dimensions.

Notebooks and Packages

The Cool Economics Pack consists of “notebooks” and “packages”. Notebooks are the user-friendly interface of *Mathematica* with the user. The packages contain the routines.

The following lists the available packages (though with the "Cool" prefix deleted):

{AGE`, Arima`, Arrowise`, Calculus`, CES`, Chainindex`, Chi2`, Common`, Context`, CrossTable`, Dbase`, Decision`, Declare`, Dictionary`, DifData`, Economic`Common`, Economic`Optimise`, Estimate`, Finance`, FlatRate`, GenePro`, GP`Estimation`, Graphics`, IADS`, Inference`, Lagrange`, Lags`, Leontief`, LevelCES`, List`, Logic`, Lseqlist`, Manager`, Matrices`, Minimax`, MissingData`, Model`, Neural`, PackLine`, ReadData`, Sampling`, ShowPlan`, Statistics`Common`, Time`, Tool` }

Technical Notes & Availability

The “Cool Economics Pack” contains about 200 files and takes 6.5 MB on hard disk. Binary files (*.mb) that control the lay-out have been deleted.

Loading all packages - and the *Mathematica* packages that are relied on - takes about 2700 KB internal memory.

The *Mathematica* packages that are relied on and which are supplied by others, are:

1. the standard packages supplied from WRI
2. for resetting: CleanSlate`
3. for Finance: the Finance Package of WRI
4. for applied general equilibrium analysis: Asahi Noguchi & Silvio Levy's MyFindRoot` (Varian (1993))
5. for math: Varian's SymbOpt` (see Varian)
6. for neural networks: Freeman (1994)

Documentation is provided in & by the notebooks only.

The software has a semi-commercial status. I've decided to give it a licensed status, and to ask a small price for it. My hope is that there will be sufficient revenue to provide for the expense of a manual and that sort of thing. For that reason, the actual pack has been split in two parts. The first part is the largest, can be freely downloaded from the internet, and contains the notebooks and documentation. The second part contains the working packages. This part is small and can be emailed upon receipt of your contribution.

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<http://www.wri.com>

Note

This is an update of the report of 1995 with the same title, Report-no: Thomas Cool 95-03. Programs have been added, others improved and integrated. This paper now is in Word for Windows, to allow for a wider distribution.