Green Paper

Economic Capital & Bank Stress Testing

The Optimal (R) Object Set

R Packages and Bundles necessary to develop Stress Testing and Economic Capital Estimations

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REvolution computing
We do the math

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We do the math

1. Introduction

1.1. The R Language

R is a free software environment for statistical computing and graphics. It compiles and runs on a wide variety of UNIX platforms, Windows and MacOS. R provides a wide variety of statistical and graphical techniques: linear and nonlinear modeling, statistical tests, time series analysis, classification, clustering, etc. Free procedure libraries are available for R, http://www.r-project.org an Open Source statistical system which was initiated by statisticians Ross Ihaka and Robert Gentleman. More and more econometricians are switching to the freely-available statistical system R.

Currently, the CRAN package repository http://cran.r-project.org/banner.shtml features 1707 R Packages including 1700 packages and 7 bundles containing 26 packages, for a total of 1726 available packages. Related is the R-Forge https://r-forge.r-project.org/ which offers a central platform for the development of R packages, R-related software and further projects. It is based on GForge offering easy access to daily built and checked packages, mailing lists, bug tracking & message boards/forums. The R-Forge has 345 projects registered today (Spring 2009) and grows monthly.

R is primarily a statistical language; R has become the de facto standard for statistical computing for quantitative finance in academia the world over. It is increasingly adopted as a useful technology within commercial organizations, in particular Investment Banks.

The key strength of R is the combination of its object oriented nature, its open source availability and it being the de facto standard for statistical computing. The advantage of this is that it is highly likely that you may never actually need to develop an object to do what you need from scratch; you can find libraries of financial Packages already developed on academic sites all over the world or join a community at your workplace. All you need to do is the analytical thinking necessary to define the modeling you need and ensure your data and its parameters are correct, then select from the 'open source' the object you require and optimize it for your implementation.

Asymptotix has argued the case for the importance of Community Open Source today to assist in achieving robust macroprudential Economic Capital Estimation predicated upon Stress Testing in the Banking and wider Financial Services Industry; in a recent presentation which is available here; http://www.asymptotix.eu/fpa.pdf

1.2. REvolution Computing

REvolution Computing www.revolution-computing.com is the leading commercial provider of software and support for the R language. REvolution's products enable statisticians, scientists and others to derive meaning from large sets of mission-critical data in record time, and to create predictive models that help to answer their most difficult questions.

Working closely with the open source R community, REvolution Computing provides the REvolution R Enterprise high-performance distribution of the R language. REvolution R Enterprise scales problems across multiple cores and networks using multithreaded numeric libraries and easy to use parallel/distributed computing extensions to the R language.

R is in essence the programming interface between your ideas of the macroeconomic factor stress test and thus quantification of risk economic capital and the analysis using technology (software and hardware) of the data required to test your propositions and thence estimate capital. R is free; it is "open source". The R Project is an ongoing initiative by the open source community, involving an international ecosystem of academics, statisticians, data miners, and others committed to the advancement of statistical computing. Through the contributions of this community, innovations in methodology can be rapidly incorporated and disseminated. R users can participate in this vibrant statistical research community by using, creating, and contributing extensions known as "packages." **REvolution Computing** provide commercial support, validation and scalability around R as a platform in order to make it a viable choice for banks and other commercial organizations as a production system, addressing open source and scalability issues.

Typically, however, unsupported installations of R in institutional finance can suffer from being limited to guru users and can place an unnecessary burden on IT and other expensive in-house resources such as quantitative analysts in model maintenance and systems support. Furthermore, use of the R language in such environments is usually confined to prototyping models only, with the expensive overhead entailed of redevelopment of these models into production development environments.

The mission of **REvolution Computing** is to enable widespread use of the R language through its supported, optimized distribution, to enable interoperability, performance, and scalability. REvolution R Enterprise allows R users to move seamlessly from exploratory analysis and rapid prototyping to production deployments. The REvolution products also ensure web services compatibility, and components required for scalability and integration as a production analytics engine for financial risk management.
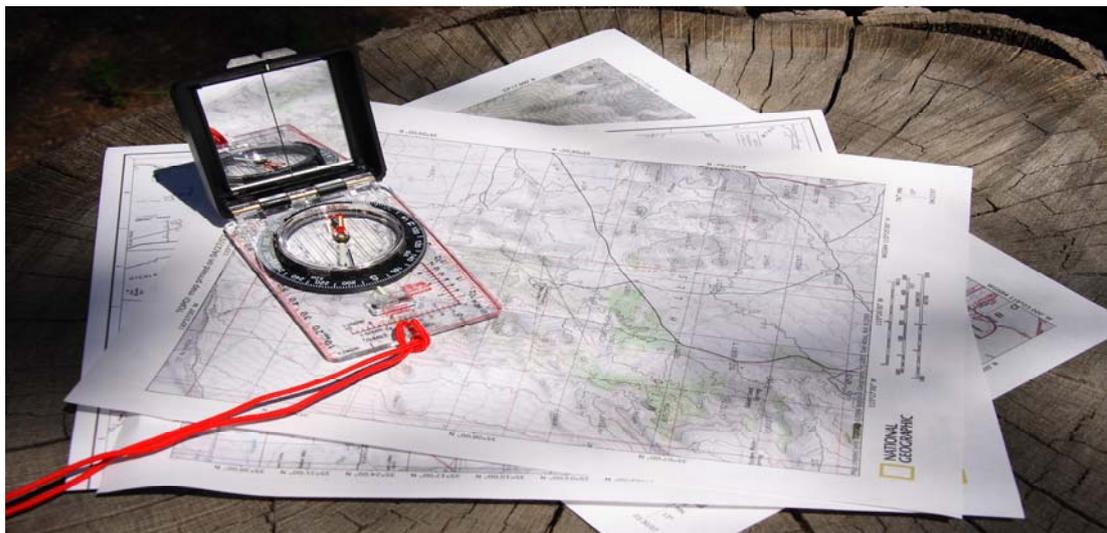
1.3. The Function of this Paper

Any analyst or Project Manager or indeed executive tasked with introducing macroprudential stress testing and risk capital estimation today is potentially going to be bewildered by the enormous riches of CRAN-R and R-Forge, a lot of the content being irrelevant to the task at hand. Without an expert eye, it is difficult to identify the subset of R Packages which can deliver quickly. Here the selection process is done for you. This list is appropriate for Credit Economic Capital Estimation, Liquidity Risk, general market risk and holistic stress testing to support total economic capital quantification, risk capital estimation and credit economic capital quantification.

The objective in setting out this list is not to be didactic; it is not setting a standard or telling you what you must use. To coin a phrase; this is principles-based advice with the objective of clarity aimed at helping you get started. When one first comes to CRAN-R (or R-Forge), particularly under time-pressure to get a quantitative job done, the list of CRAN-R-Packages does seem bewildering since there are packages there designed to do specific jobs in psychology, ecology, medicine and electronics. This paper provides an analysis which is intended to sort out the wood from the trees for a new user trying to estimate Economic Risk Capital or to conduct some Stress Testing.

This volume of software Packages (on CRAN-R or R-Forge) can be confusing because the forges are not really organized specifically for someone trying to quantitatively estimate economic capital but it is also the case that many Packages developed for bioscience or ecology (or any other scientific discipline) are Packages very appropriate to risk management, one just has to get the point of the body of the theoretical work in the area of Stress Testing and Risk Capital estimation generally to grasp that point.

1.4. A Theory Framework

This summary has to be read in the context of the specifications of Stress Testing techniques & Economic Capital estimation methodologies which **Asymptotix** has been collecting into a single locus under the "theory-forge" banner otherwise it makes no sense; you have "how" but not the "why". **Asymptotix** has provided a methodological exposition of the 'Theory-Forge' concept and process recently; http://www.analyticbridge.com/profiles/blogs/what-am-i-doing-with-my

Essentially we are calling for the theoretical framework underlying the process of stress testing and economic capital estimation to be consolidated in one single locus, where important contributions to the theoretical cannon in this topic can be brought together from disparate sources. This has to be done since economic capital estimation is now such a crucial aspect not only of corporate governance but of the political stewardship of our democratic society. **Asymptotix** can make a 'first stab' at that collation as a by product of its work as a consulting adviser but anything that we do will always remain our specific personal perspective.

The "theory forge" idea grew from the development of a 'White Paper' (WP) which Asymptotix developed with **Revolution Computing**; http://www.revolution-computing.com/index.php this year (2009); the references to which, reflect the state of the art in terms of Economic Risk Capital estimation and Stress testing; the paper is available here; http://www.asymptotix.eu/ecap.pdf and the references are available separately here; http://www.asymptotix.eu/node/94 A related set of references is available here http://www.asymptotix.eu/node/88 These references can be regarded as asymptotix contribution to 'kick-starting' the consolidated theoretical repository concept.

The WP referred above is an exposition of how crucial both in terms of banking supervision and in terms of the individual bank's strength, economic capital has become. The paper precisely defines economic capital both at the single institution level and at the systemic level. The WP demonstrates that best practice and supervisory requirements entail that every financial institution must calculate an appropriate quantum of economic return on an originated exposure, risk based position or portfolio. Further the WP reveals how such a quantum of economic return is estimated or predicted based upon quantitative techniques or statistical analytics. Thus the WP is the basis of what we refer to as the theory forge.

Academic publications are pouring forth right now (Spring 2009) and new ideas out of the Central Banks in Europe are appearing weekly. Applied research in quantitative risk management has accelerated like a sports-car in response to the Credit Crisis. New, good, applied and theoretical papers are appearing almost daily, which are relevant in the process of selecting the optimal quantitative toolset to implement Economic Risk Capital estimation in a commercial financial institution. The **Asymptotix** Risk Research blogs attempt to keep abreast of this developing resource in current time so that theoretically our audience can be up to date and thus make informed decisions at the practical toolset and software object level. The blog links are here; http://www.asymptotix.eu/ab and here; http://www.asymptotix.eu/blog/7

1.4.1. Legacy WP - ASRF

It has also been noted recently that a longer WP published by the software mega-vendor SAP in the spring of 2006 (but written by the author of this paper) has been identified by quantitatively focused members of the social networking site Analytic Bridge http://www.analyticbridge.com/ as relevant and important in the development of (current) applied work in Economic Risk Capital estimation; that paper is available here; http://www.sap.com/uk/images/baselii/whitepaper.pdf

In the chapter called "The Calculus of Structured Finance", the WP focused upon the Basel rules for the computation of regulatory and economic capital in issued structured instruments (i.e. capital to be held by the issuer). This is arguably the key single Basel rule which by being broken caused the Credit Crunch and thus is relevant here. That WP argues that; "In securitisation it's different"! At the baseline, the Economic Capital and Regulatory Capital numbers are identical (they were conflated methodologically by Basel II [but not observed]). As that WP argued in 2006; "the challenge in securitisation will be to provide stressed measures of Economic Capital for securitisation issuance (and investment); this is complex simply by virtue of the instrument complexity."

The key logic of the exposition of Risk Capital quantification in Structured Finance (the "Calculus") in that WP relies on the work of Professor Michael Gordy of the Federal Reserve and in particular the Asymptotic Single Risk Factor (ASRF) framework, the basis of the un-enforced, un-observed Basel rule which led to the credit crisis. For this paper, Gordy's logic as to why quantitative techniques are fundamental to risk capital questions is relevant. The paper argues that; "the shortcomings of the Discounted Cash Flow (DCF) approach to valuation are well recognised; DCF misses key elements of total return, the absence of a market value basis omits important information necessary to more fully judge performance going forward and volatility in valuation expectations i.e. significant market value adjustments are ignored. This means that the cash flow of the receivables for a securitised instrument, although an important fundamental aspect of the valuation process is not the end of the process and should not be recognised as such." Essentially the accounting certainty is a chimera. This reflects a key critique of Structural Models in general which developed in the mid-90s; that is that Structural Models which rely on quantification of the firms assets and (in particular) liabilities in a precise (accounting) manner are seriously "punctured" or appear flawed when we introduce and assumption that accounting information is uncertain.

Asymptotix has recently reflected upon the relevance and importance of the ASRF today and the reasons why it cannot be ignored; here: http://www.asymptotix.eu/node/87 and here: http://www.asymptotix.eu/node/86

1.5. Caveats and Critiques

The selection here is a personal view. The selection inevitably may be quite controversial, readers may ask, "Why is that object there and not this one etc?" The exposition is a "first stab", to help a department or unit get started in this macroprudential stress testing and capital estimation process which is going to be more rigorously enforced and executive-demanded in the coming years.

This exposition is a consolidation of the object set necessary to meet the specific requirement, drawn from consulting advice and project experience over recent years. As far as we at **asymptotix** are aware, there is nothing like this "out there", in the public domain right now and the only reason we are making a first stab at it is because noone else has. This is the subset of CRAN-R which is of interest to asymptotix professionally, the set of Packages which we use or are interested in, as such it is a personal collection, which may be of interest and practical use to others.

We invite feedback and comment @ info@asymptotix.eu

2. Core R Packages - (Bank Supervisory) Stress Testing and Economic Capital Estimation

Package / Bundle / Object	Description	url
Core or Key R Packages		
AER: Applied Econometrics with R	Functions, data sets, examples, demos, and vignettes for the book Christian Kleiber and Achim Zeileis (2008), Applied Econometrics with R, Springer-Verlag, New York. ISBN 978-0-387-77316-2.	http://cran.r-project.org/web/packages/AER/index.html
actuar: Actuarial functions	Additional actuarial science functionality, mostly in the fields of loss distributions, risk theory (including ruin theory), simulation of compound hierarchical models and credibility theory, for the moment.	http://cran.r-project.org/web/packages/actuar/index.html
asympTest: Asymptotic statistic	Asymptotic testing	http://cran.r-project.org/web/packages/asympTest/index.html
bayesGARCH: Bayesian Estimation of the GARCH(1,1) Model with Student-t Innovations	This package provides the bayesGARCH function which performs the Bayesian estimation of the GARCH(1,1) model with Student's t innovations.	http://cran.r-project.org/web/packages/bayesGARCH/index.html
bbmle: Tools for general maximum likelihood estimation	Methods and functions for fitting maximum likelihood models in R. This package modifies and extends the mle classes in the stats4 package.	http://cran.r-project.org/web/packages/bbmle/index.html
copula: Multivariate dependence with copulas	Classes (S4) of commonly used copulas including elliptical (normal and t), Archimedean (Clayton, Gumbel, Frank, and Ali-Mikhail-Haq), extreme value (Husler-Reiss and Galambos), and other families (Plackett and Farlie-Gumbel-Morgenstern). Methods for density, distribution, random number generation, bivariate dependence measures, perspective and contour plots. Functions for fitting copula models with variance estimate. Independence tests among random variables and random vectors. Serial independence tests for univariate and multivariate continuous time series. Goodness-of-fit tests for copulas based on multipliers and on the parametric bootstrap.	http://cran.r-project.org/web/packages/copula/index.html

Package / Bundle / Object	Description	url
Core or Key R Packages		
dyn: Time Series Regression	Time series regression. The dyn class interfaces ts, irts, its, zoo and zooreg time series classes to lm, glm, loess, quantreg::rq, MASS::rlm, MCMCpack::MCMCregress, quantreg::rq, randomForest::randomForest and other regression functions allowing those functions to be used with time series including specifications that may contain lags, diffs and missing values.	http://cran.r-project.org/web/packages/dyn/index.html
dynlm: Dynamic Linear Regression	Dynamic linear models and time series regression. The package is supported by an example analyzing German demand for M1.	http://cran.r-project.org/web/packages/dynlm/index.html
evd: Functions for extreme value distributions	Extends simulation, distribution, quantile and density functions to univariate and multivariate parametric extreme value distributions, and provides fitting functions which calculate maximum likelihood estimates for univariate and bivariate maxima models, and for univariate and bivariate threshold models.	http://cran.r-project.org/web/packages/evd/index.html
evir: Extreme Values in R	Functions for extreme value theory, which may be divided into the following groups; exploratory data analysis, block maxima, peaks over thresholds (univariate and bivariate), point processes, gev/gpd distributions.	http://cran.r-project.org/web/packages/evir/index.html
fArma: ARMA Time Series Modelling	A collection and description of simple to use functions to model univariate autoregressive moving average time series processes, including time series simulation, parameter estimation, diagnostic analysis of the fit, and predictions of future values.	http://cran.r-project.org/web/packages/fArma/index.html
fBonds: Bonds and Interest Rate Models	Term Structure Modeling	http://cran.r-project.org/web/packages/fBonds/index.html
fCopulae: Rmetrics - Dependence Structures with Copulas	Copula and Extreme Value Theory http://cran.r-project.org/web/packages/fCopulae/fCopulae.pdf	http://cran.r-project.org/web/packages/fCopulae/index.html
fExtremes: Rmetrics - Extreme Financial Market Data	Extreme Values	http://cran.r-project.org/web/packages/fExtremes/index.html

Package / Bundle / Object	Description	url
Core or Key R Packages		
gogarch: Generalized Orthogonal GARCH (GO-GARCH) models	Implementation of the GO-GARCH model class	http://cran.r-project.org/web/packages/gogarch/index.html https://r-forge.r-project.org/projects/gogarch/
gumbel: Gumbel copula	Stand alone package providing R functions for the Gumbel-Hougaard copula. We provide probality functions (cumulative distribution and density functions), simulation function (Gumbel copula multivariate simulation) and estimation functions (Maximum Likelihood Estimation, Inference For Margins, Moment Based Estimation and Canonical Maximum Likelihood).	http://cran.r-project.org/web/packages/gumbel/index.html
mlCopulaSelection: Copula selection and fitting using maximum likelihood	Use numerical maximum likelihood to choose and fit a bivariate copula model (from a library of 40 models) to the data.	http://cran.r-project.org/web/packages/mlCopulaSelection/index.html
nlme: Linear and Nonlinear Mixed Effects Models	Fit and compare Gaussian linear and nonlinear mixed-effects models.	http://cran.r-project.org/web/packages/nlme/index.html
QRMlib: Provides R-language code to examine Quantitative Risk Management concepts	This is a free R-language library designed to accompany the book Quantitative Risk Management: Concepts, Techniques and Tools by Alexander J. McNeil, Rudiger Frey and Paul Embrechts. A separate SPlus version can be downloaded from Alexander McNeil's URL at http://www.ma.hw.ac.uk/~mcneil/book/QRMlib.html	http://cran.r-project.org/web/packages/QRMlib/index.html
AICTS I (urca)	Unit root and cointegration tests encountered in applied econometric analysis http://www.pfaffikus.de/	https://r-forge.r-project.org/projects/urca/
AICTS II (VARs)	VAR, SVAR, VECM and SVECM models: Estimation, prediction, impulse response analysis, forecast error variance decomposition, diagnostic testing	https://r-forge.r-project.org/projects/vars/

Package / Bundle / Object	Description	url
Core or Key R Packages		
Depmix S4	depmix fits hidden Markov models on (multivariate) time series, subject to general linear constraints on the parameters. Response distributions include glm models and the multinomial logit; transitions are time dependent through the use of covariates.	https://r-forge.r-project.org/projects/depmix/
FinTS	To create a companion package for Ruey Tsay (2005) Analysis of Financial Time Series, 2nd ed. (Wiley), includes Value at Risk,	https://r-forge.r-project.org/projects/fints/

3. Advanced Packages - Stress Testing Process

Package / Bundle / Object Name	Description	url
Advanced / Sophisticated Packages		
Amelia: Amelia II: A Program for Missing Data	Amelia II "multiply imputes" missing data in a single cross-section (such as a survey), from a time series (like variables collected for each year in a country), or from a time-series-cross-sectional data set (such as collected by years for each of several countries). Amelia II implements our bootstrapping-based algorithm that gives essentially the same answers as the standard IP or EMis approaches, is usually considerably faster than existing approaches and can handle many more variables.	http://cran.r-project.org/web/packages/Amelia/index.html
accuracy: Tools for testing and improving	a suite of tools designed to test and improve the accuracy of statistical computation	http://cran.r-project.org/web/packages/accuracy/index.html

Package / Bundle / Object Name	Description	url
Advanced / Sophisticated Packages		
AMORE: A MORE flexible neural network package	This package was born to release the TAO robust neural network algorithm to the R users. It has grown and I think it can be of interest for the users wanting to implement their own training algorithms as well as for those others whose needs lie only in the "user space".	http://cran.r-project.org/web/packages/AMORE/index.html
amap: Another Multidimensional Analysis Package	Tools for Clustering and Principal Component Analysis (With robusts methods, and parallelized functions).	http://cran.r-project.org/web/packages/amap/index.html
arm: Data Analysis Using Regression and Multilevel/Hierarchical Models	R functions for processing lm, glm, mer and polr outputs.	http://cran.r-project.org/web/packages/arm/index.html
bayesSurv: Bayesian Survival Regression with Flexible Error and Random Effects Distributions	Bayesian Survival Regression with Flexible Error and Random Effects Distributions	http://cran.r-project.org/web/packages/bayesSurv/index.html
ccgarch: Conditional Correlation GARCH models	Functions for estimating and simulating the family of the CC-GARCH models.	http://cran.r-project.org/web/packages/ccgarch/index.html
convexHaz: Nonparametric MLE/LSE of convex hazard	This package contains functions to compute the nonparametric maximum likelihood estimator (MLE) and the nonparametric least squares estimator (LSE) of a convex hazard function, assuming that the data is IID.	http://cran.r-project.org/web/packages/convexHaz/index.html
dlm: Bayesian and Likelihood Analysis of Dynamic Linear Models	Maximum likelihood, Kalman filtering and smoothing, and Bayesian analysis of Normal linear State Space models, also known as Dynamic Linear Models	http://cran.r-project.org/web/packages/dlm/index.html

Package / Bundle / Object Name	Description	url
Advanced / Sophisticated Packages		
dr: Methods for dimension reduction for regression	Functions, methods, and datasets for fitting dimension reduction regression, using slicing (methods SAVE and SIR), Principal Hessian Directions. Partial methods, that condition on categorical predictors are also available. A variety of tests, and stepwise deletion of predictors, is also included. Also included is code for computing permutation tests of dimension. Adding additional methods of estimating dimension is straightforward. For documentation, see the vignette in the package. Version 3.0.1 corrects an error in psir and psave first detected with R 2.8.0.	http://cran.r-project.org/web/packages/dr/index.html
evdbayes: Bayesian Analysis in Extreme Value Theory	Provides functions for the bayesian analysis of extreme value models, using MCMC methods.	http://cran.r-project.org/web/packages/evdbayes/index.html
FKF: Fast Kalman Filter	This is a flexible implementation of the Kalman filter. It is entirely written in C and relies fully on linear algebra subroutines contained in BLAS and LAPACK. Due to the speed of the filter, the fitting of high-dimensional linear state space models to large datasets becomes possible. This package also contains a plot function for the visualization of the state vector and graphical diagnostics of the residuals.	http://cran.r-project.org/web/packages/FKF/index.html
gsarima: Two functions for Generalized SARIMA time series simulation	Write SARIMA models in (finite) AR representation and simulate generalized multiplicative seasonal autoregressive moving average (time) series with Normal / Gaussian, Poisson or negative binomial distribution.	http://cran.r-project.org/web/packages/gsarima/index.html

Package / Bundle / Object Name	Description	url
Advanced / Sophisticated Packages		
MSBVAR: Markov-Switching Bayesian Vector Autoregression Models	Provides methods for estimating frequentist and Bayesian Vector Autoregression (VAR) models. Functions for reduced form and structural VAR models are also available. Includes methods for the generating posterior inferences for VAR forecasts, impulse responses (using likelihood-based error bands), and forecast error decompositions. Also includes utility functions for plotting forecasts and impulse responses, and generating draws from Wishart and singular multivariate normal densities. Future versions will include some models with Markov switching.	http://cran.r-project.org/web/packages/MSBVAR/index.html
mixPHM: Mixtures of proportional hazard models	This package fits multiple variable mixtures of various parametric proportional hazard models using the EM-Algorithm. Proportionality restrictions can be imposed on the latentgroups and/or on the variables. Several survival distributions can be specified. Missing values and censored values are allowed. Independence is assumed over the single variables.	http://cran.r-project.org/web/packages/mixPHM/index.html
mlegp: Maximum Likelihood Estimates of Gaussian Processes	Maximum likelihood Gaussian process modeling for univariate and multi-dimensional outputs with diagnostic plots and sensitivity analysis.	http://cran.r-project.org/web/packages/mlegp/index.html

Package / Bundle / Object Name	Description	url
Advanced / Sophisticated Packages		
mmlcr: Mixed-Mode Latent Class Regression	mmlcr is an Splus/R library for mixed-mode latent class regression (also known as mixed-mode mixture model regression or mixed-mode mixture regression models) which can handle both longitudinal and one-time responses. By mixed-mode, I mean that the manifest variables can be of mixed types: some longitudinal, some one-time, some normal, some censored-normal, some categorical, some Poisson. The software is written completely in Splus code and is built around the EM algorithm. It is slow but very flexible.	http://cran.r-project.org/web/packages/mmlcr/index.html
muhaz: Hazard Function Estimation in Survival Analysis	A package for producing a smooth estimate of the hazard function for censored data.	http://cran.r-project.org/web/packages/muhaz/index.html
nlts: (non)linear time series analysis	R functions for (non)linear time series analysis. A core topic is order estimation through cross-validation.	http://cran.r-project.org/web/packages/nlts/index.html
tsfa: Time Series Factor Analysis	Extraction of Factors from Multivariate Time Series. http://cran.r-project.org/web/packages/tsfa/vignettes/tsfa.pdf	http://cran.r-project.org/web/packages/tsfa/index.html
WhatIf: Software for Evaluating Counterfactuals	WhatIf implements the methods for evaluating counterfactuals discussed in Gary King and Langche Zeng, 2006, "The Dangers of Extreme Counterfactuals," Political Analysis 14 (2); and Gary King and Langche Zeng, 2007, "When Can History Be Our Guide? The Pitfalls of Counterfactual Inference," International Studies Quarterly 51	http://cran.r-project.org/web/packages/WhatIf/index.html

Package / Bundle / Object Name	Description	url
Advanced / Sophisticated Packages		
The POT package	The POT package aims to provide operational tools to analyze POT. This package relies on the EVT to model the tail of any continuous distribution. Tail modelling, in particular POT modelling, is of great importance for many financial and environmental applications. http://pot.r-forge.r-project.org/	https://r-forge.r-project.org/projects/pot/

4. Packages for Financial Predictive Analytics

These may be applicable in Stress Testing.

Package / Bundle / Object Name	Description	url
Specific Econometric Packages		
CDNmoney: Components of Canadian Monetary and Credit Aggregates	Components of Canadian Credit Aggregates and Monetary Aggregates with continuity adjustments. http://www.bank-banque-canada.ca/pgilbert/	http://cran.r-project.org/web/packages/CDNmoney/index.html
CreditMetrics: Functions for calculating the CreditMetrics risk model	A set of functions for computing the CreditMetrics risk model	http://cran.r-project.org/web/packages/CreditMetrics/index.html
Ecdat: Data sets for econometrics	Data sets for econometrics Miscellaneous Econometric Analytics	http://cran.r-project.org/web/packages/Ecdat/index.html
fame: Interface for FAME time series database	Read and write FAME databases.	http://cran.r-project.org/web/packages/fame/index.html
financial: Solving financial problems in R	Time value of money, cash flows and other financial functions.	http://cran.r-project.org/web/packages/financial/index.html
fxregime: Exchange Rate Regime Analysis	Exchange rate regression and structural change tools for estimating, testing, dating, and monitoring (de facto) exchange rate regimes.	http://cran.r-project.org/web/packages/fxregime/index.html
PerformanceAnalytics: Econometric tools for performance and risk analysis	Library of econometric functions for performance and risk analysis. This library aims to aid practitioners and researchers in utilizing the latest research in analysis of non-normal return streams. In general, this library is most tested on return (rather than price) data on a monthly scale, but most functions will work with daily or irregular return data as well.	http://cran.r-project.org/web/packages/PerformanceAnalytics/index.html

Package / Bundle / Object Name	Description	url
Specific Econometric Packages		
portfolio: Analysing equity portfolios	Classes for analyzing and implementing equity portfolios.	http://cran.r-project.org/web/packages/portfolio/index.html
RQuantLib: R interface to the QuantLib library	Currently some basic option pricing functions are included, as well as fixed-income functions that can be used for interest rate curve construction and Bermuda swaption pricing. Further software contributions are welcome. The QuantLib project aims to provide a comprehensive software framework for quantitative finance.	http://cran.r-project.org/web/packages/RQuantLib/index.html
tseries: Time series analysis and computational finance	Package for time series analysis and computational finance Macroeconometric Time series	http://cran.r-project.org/web/packages/tseries/index.html
blotter	- trade simulation infra - Transaction-oriented infrastructure for defining instruments, transactions, portfolios and accounts for trading systems and simulation. Intends to provide portfolio support for multi-asset class and multi-currency portfolios. Still in heavy development.	https://r-forge.r-project.org/projects/blotter/
QuantLab	The package QuantLab contains a collection of R-commands, which support computer experiments in the fields of probability, stochastic processes, stochastic analysis and mathematical finance. (Structured Products)	https://r-forge.r-project.org/projects/quantlab/
Rmetrics	Rmetrics is an open source solution for teaching financial market analysis and valuation of financial instruments. With hundreds of functions build on modern methods, Rmetrics combines explorative data analysis and statistical modeling. It's Impressive!!	https://r-forge.r-project.org/projects/rmetrics/

5. Useful Utilities - Stress Testing

Package / Bundle / Object Name	Description	url
Useful Utilities		
BootPR: Bootstrap Prediction Intervals and Bias-Corrected Forecasting	Bias-Corrected Forecasting and Bootstrap Prediction Intervals for Autoregressive Time Series	http://cran.r-project.org/web/packages/BootPR/index.html
backtest: Exploring portfolio-based conjectures about financial instruments	The backtest package provides facilities for exploring portfolio-based conjectures about financial instruments (stocks, bonds, swaps, options, et cetera).	http://cran.r-project.org/web/packages/backtest/index.html
gmm: Generalized Method of Moments and Generalized Empirical Likelihood	It is a complete suite to estimate models based on moment conditions. It includes the two step Generalized method of moments (GMM) of Hansen(1982), the iterated GMM and continuous updated estimator (CUE) of Hansen-Eaton-Yaron(1996) and several methods that belong to the Generalized Empirical Likelihood (GEL) family of estimators.	http://cran.r-project.org/web/packages/gmm/index.html
hlr: Hidden Logistic Regression	Package implementing the methods described in Rousseeuw and Christman (2003) to cope with separation issues and outliers in logistic regression	http://cran.r-project.org/web/packages/hlr/index.html
hyperdirichlet: A generalization of the Dirichlet distribution	A suite of routines for the hyperdirichlet distribution	http://cran.r-project.org/web/packages/hyperdirichlet/index.html
impute: Imputation for microarray data	Imputation for microarray data (currently KNN only)	http://cran.r-project.org/web/packages/impute/index.html
its: Irregular Time Series	The its package contains an S4 class for handling irregular time series	http://cran.r-project.org/web/packages/its/index.html

Package / Bundle / Object Name	Description	url
Useful Utilities		
mAr: Multivariate AutoRegressive analysis	R functions for multivariate autoregressive analysis	http://cran.r-project.org/web/packages/mAr/index.html
maxLik: Maximum Likelihood Estimation	Tools for Maximum Likelihood Estimation	http://cran.r-project.org/web/packages/maxLik/index.html
mitools: Tools for multiple imputation of missing data	Tools to perform analyses and combine results from multiple-imputation datasets.	http://cran.r-project.org/web/packages/mitools/index.html
pcaPP: Robust PCA by Projection Pursuit	Robust PCA by Projection Pursuit	http://cran.r-project.org/web/packages/pcaPP/index.html
robfilter: Robust Time Series Filters	A set of functions to filter time series based on concepts from robust statistics.	http://cran.r-project.org/web/packages/robfilter/index.html
sandwich: Robust Covariance Matrix Estimators	Model-robust standard error estimators for cross-sectional, time series and longitudinal data.	http://cran.r-project.org/web/packages/sandwich/index.html
timeDate: Rmetrics - Chronological and Calendarical Packages	The 'timeDate' class fulfils the conventions of the ISO 8601 standard as well as of the ANSI C and POSIX standards. Beyond these standards Rmetrics has added the "Financial Center" concept which allows one to handle data records collected in different time zones but to have always the proper time stamps with respect to your personal financial center, or alternatively to the GMT reference time. It can thus also handle time stamps from historical data records from the same time zone, even if the financial centers changed day light saving times at different calendar dates.	http://cran.r-project.org/web/packages/timeDate/index.html

Package / Bundle / Object Name	Description	url
Useful Utilities		
timeSeries: Rmetrics - Financial Time Series Packages	'timeSeries' Packages can be created in several ways. One can create them from scratch, or one can read them from a file. If we have a file it is assumed that the first column holds a character string with the date/time positions, named "charvec", and the remaining column(s), depending if we consider the univariate or multivariate case the numeric time series records named "data".	http://cran.r-project.org/web/packages/timeSeries/index.html
xts: Extensible Time Series	Provide for uniform handling of R's different time-based data classes by extending zoo, maximizing native format information preservation and allowing for user level customization and extension, while simplifying cross-class interoperability.	http://cran.r-project.org/web/packages/xts/index.html
zoo: Z's ordered observations	An S3 class with methods for totally ordered indexed observations. It is particularly aimed at irregular time series of numeric vectors/matrices and factors. zoo's key design goals are independence of a particular index/date/time class and consistency with with ts and base R by providing methods to extend standard generics.	http://cran.r-project.org/web/packages/zoo/index.html
The blupsurv Package	The blupsurv package contains tools for fitting proportional hazards models to clustered univariate or bivariate recurrent event data. http://blupsurv.r-forge.r-project.org/	https://r-forge.r-project.org/projects/blupsurv/

Package / Bundle / Object Name	Description	url
Useful Utilities		
Bpca	The bpca package implements biplot (2d and 3d) of multivariate data based in principal components analysis and provide diagnostic tools of the quality of the reduction.	https://r-forge.r-project.org/projects/bpca/
robKalman	Package robKalman implements several robustifications of the classical Kalman filter; a common filtering interface for all robustifications is provided as well as S4-classes for state space models and filtering results.	https://r-forge.r-project.org/projects/robkalman/
robust-ts	"robust-ts" is a collaborative project to provide robustifications to the basic time series procedures from package stats. A target will be chapter 8 in "Robust Statistics, Theory and Methods" by Maronna, Martin and Yohai; 2006.	https://r-forge.r-project.org/projects/robust-ts/

6. Advanced (Non-Econometric) R Packages - potential Econometric Applications

In this section I have only selected Packages which have clear and obvious application to Stress testing and Economic Capital estimation. There are other R Packages which I believe, after detailed consideration could be brought to bear upon Economic Risk Capital issues from other disciplines. This subset however is sufficient for initial consideration by a team undertaking some forensic applied work.

Package / Bundle / Object Name	Description	url
Advanced (Non-Econometric) R Packages		
bayesSurv: Bayesian Survival Regression with Flexible Error and Random Effects Distributions	http://www.karlin.mff.cuni.cz/~komarek/software.html http://www.karlin.mff.cuni.cz/~komarek/publications/COMSTA-3853.pdf	http://cran.r-project.org/web/packages/bayesSurv/index.html
bnlearn: Bayesian network structure learning	Bayesian network structure learning via constraint-based (also known as 'conditional independence') and score-based algorithms.	http://cran.r-project.org/web/packages/bnlearn/index.html
boa: Bayesian Output Analysis Program (BOA) for MCMC	A menu-driven program and library of functions for carrying out convergence diagnostics and statistical and graphical analysis of Markov chain Monte Carlo sampling output.	http://cran.r-project.org/web/packages/boa/index.html
gnm: Generalized Nonlinear Models	Functions to specify and fit generalized nonlinear models, including models with multiplicative interaction terms such as the UNIDIFF model from sociology and the AMMI model from crop science, and many others. Over-parameterized representations of models are used throughout; functions are provided for inference on estimable parameter combinations, as well as standard methods for diagnostics etc.	http://cran.r-project.org/web/packages/gnm/index.html

Package / Bundle / Object Name	Description	url
Advanced (Non-Econometric) R Packages		
imputeMDR: The Multifactor Dimensionality Reduction (MDR) Analysis for Incomplete Data	This provides various approaches to handling missing values for the MDR analysis	http://cran.r-project.org/web/packages/imputeMDR/index.html
iid.test	Testing whether data is independent and identically distributed	http://cran.r-project.org/web/packages/iid.test/index.html
lme4: Linear mixed-effects models using S4 classes	Fit linear and generalized linear mixed-effects models.	http://cran.r-project.org/web/packages/lme4/index.html
MCMCglmm: MCMC Generalised Linear Mixed Models	MCMC Generalized Linear Mixed Models	http://cran.r-project.org/web/packages/MCMCglmm/index.html
mi: Missing Data Imputation and Model Checking	Missing Data Imputation and Model Checking http://www.stat.columbia.edu/~gelman/	http://cran.r-project.org/web/packages/mi/index.html https://r-forge.r-project.org/projects/mi-dev/
mmlcr: Mixed-Mode Latent Class Regression	Mixed-mode latent class regression (also known as mixed-mode mixture model regression or mixed-mode mixture regression models) which can handle both longitudinal and one-time responses, although it is created with longitudinal data in mind.	http://cran.r-project.org/web/packages/mmlcr/index.html
ouch: Ornstein-Uhlenbeck models for phylogenetic comparative hypotheses	Fit and compare Ornstein-Uhlenbeck models for evolution along a phylogenetic tree.	http://cran.r-project.org/web/packages/ouch/index.html

Package / Bundle / Object Name	Description	url
Advanced (Non-Econometric) R Packages		
PMA: Penalized Multivariate Analysis	Performs Penalized Multivariate Analysis: a penalized matrix decomposition, sparse principal components analysis, and sparse canonical correlation analysis, described in the following paper: Witten, Tibshirani and Hastie (2009) penalized matrix decomposition, with applications to sparse principal components and canonical correlation analysis.	http://cran.r-project.org/web/packages/PMA/index.html
PSM: Non-Linear Mixed-Effects modelling using Stochastic Differential Equations	This package provides functions for estimation of linear and non-linear mixed-effects models using stochastic differential equations. Moreover it provides functions for finding smoothed estimates of model states and for simulation. The package allows for any multivariate non-linear time-variant model to be specified and it also handels multidimensional input, co-variates & missing observations.	http://cran.r-project.org/web/packages/PSM/index.html
tseriesChaos: Analysis of nonlinear time series	Routines for the analysis of nonlinear time series. http://www.mpipks-dresden.mpg.de/~tisean/Tisean_3.0.1/index.html Chaos Theory and Time series	http://cran.r-project.org/web/packages/tseriesChaos/index.html

7. Other Generally Interesting Econometric Packages

Package / Bundle / Object Name	Description	url
Econometric functions		
frontier: Stochastic Frontier Analysis	Maximum Likelihood Estimation of Stochastic Frontier Production and Cost Functions. Two specifications are available: the error components specification with time-varying efficiencies (Battese and Coelli, 1992) and a model specification in which the firm effects are directly influenced by a number of variables (Battese and Coelli, 1995).	http://cran.r-project.org/web/packages/frontier/index.html https://r-forge.r-project.org/projects/frontier/
micEcon: Microeconomic Analysis and Modelling	micEcon is an extension package for the "language and environment for statistical computing and graphics" called R. micEcon provides functions for microeconomic analysis and microeconomic modeling. http://www.micecon.org/	http://cran.r-project.org/web/packages/micEcon/index.html
sem: Structural Equation Models	This package contains functions for fitting general linear structural equation models (with observed and unobserved variables) by the method of maximum likelihood using the RAM approach, and for fitting structural equations in observed-variable models by two-stage least squares. Data for Klein's (1950) simple econometric model of the U. S. economy.	http://cran.r-project.org/web/packages/sem/index.html https://r-forge.r-project.org/projects/sem/
skewt: The Skewed Student-t Distribution	Density, distribution function, quantile function and random generation for the skewed t distribution of Fernandez and Steel.	http://cran.r-project.org/web/packages/skewt/index.html
sn: The skew-normal and skew-t distributions	Functions for manipulating skew-normal and skew-t probability distributions, and for fitting them to data, in the scalar and in the multivariate case.	http://cran.r-project.org/web/packages/sn/index.html

8. Enterprise Solution Architecture for Risk Management

The source of the Credit Crisis was in large part crucial failures in internal reporting and IT systems which comply with "Transparency Standards". The Transparency Standards are being toughened by the Governments worldwide, right now; to be defined finally after the G20 in London in April 2009. There is general consensus that the banks and insurance companies never even met the transparency standards in place in 2006 (pre Crisis). Now they are being 'enhanced', 'tightened'. There is no question that in general black box proprietary closed source predictive analytics have failed the banking industry and thus society. On the other hand the large scale data management platforms for banking from IBM and SAP cannot be dismissed nor bettered. They have invested so much intellectual capital in these platforms it would take millennia for Open Source to catch up in that layer of the stack. The next step has to be about Open Source, almost certainly with a commercial backing in terms of support. Open Source is not exclusively about Predictive Analytics, it's just that the Community aspect is eminently applicable to predictive analytics, since the problems are generally hard and are generally iteratively solved.

Through Community sharing, statisticians and economists in the banks can begin the process of development of macroeconomic through the cycle risk and capital quantification. The key business accelerator in Open Source is Community, particularly in Financial Predictive Analytics; since it is via the community in an open source framework that one's initial intellectual capital is gathered.

8.1. Risk Management and Financial Predictive Analytics (FPA)

On this page of the **asymptotix** website; http://www.asymptotix.eu/important-references you will find the key references to a methodology and approach to developing the solution architecture for Financial Predictive Analytics in Banking and Insurance. For a more detailed understanding we would recommend that you follow the links to the important reference material on the related pages of the website.

8.2. REvolution R Enterprise

REvolution R Enterprise is Optimized

In addition to the performance optimizations included in all versions of REvolution R (http://revolution-computing.com/products/r-performance.php), additional performance features are included in REvolution R Enterprise, such as ParallelR to significantly speed time to results in multiprocessor environments, including multicore workstations. The Cluster Edition extends ParallelR to include integration with scheduling systems, including full support for Windows HPC environments, and fault-tolerant processing, which enables your calculation to complete even if one or more of your worker nodes goes offline during processing. ParallelR detects the fault, and automatically re-routes the remaining computations to the surviving worker nodes. Read more about reducing computation times using ParallelR for parallel and distributed processing: http://revolution-computing.com/products/parallel-r.php.
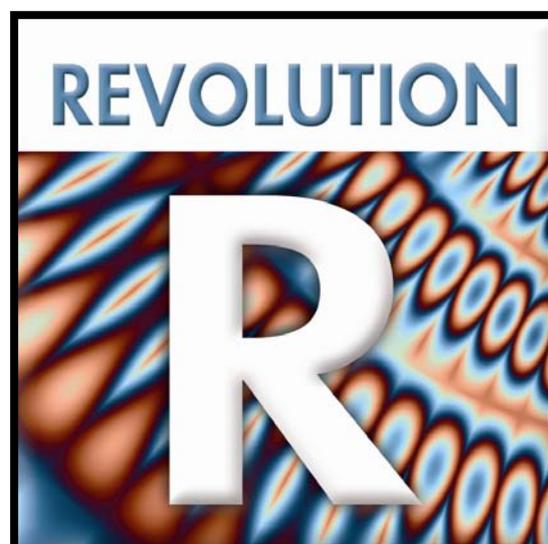
REvolution R Enterprise is validated

The word "validation" has different meanings, depending upon the industry but for all products REvolution applies an extensive testing and build process within a controlled, documented, software development lifecycle. If you're looking for a platform for validated statistical analysis in a regulated environment such as life sciences and finance, consider Revolution R Enterprise for the stability and long-term support you'll require. Read more about running REvolution R Enterprise in a validated environment: http://revolution-computing.com/products/enterprise-validation.php.

REvolution R Enterprise is Fully Supported

REvolution R Enterprise is backed by the resources and expertise of REvolution Computing, a private software company founded to promote the use of R in commercial environments:

- REvolution configures, build, test and distribute regular stable releases based on the open-source R project.
- REvolution provides extensive documentation that helps new users of R get up and running quickly.
- REvolution provides an environment for REvolution R users to interact with a community of peers in our web-based technical forums and community portal.
- Live, professional technical support is included with every REvolution R Enterprise subscription. Our experts in statistics, computer-science, and the R programming environment are there to support your use of R and answer your questions. Read more about available technical support subscription levels: http://revolution-computing.com/support/.
- REvolution offer training (http://revolution-computing.com/products/training/) for new or experienced users and consulting services (http://revolution-computing.com/products/consulting/) to help companies get the most out of their investment in R.

Leveraging REvolution's products and services to deliver high performance distributions of R across all platforms, backed by full support, enables you to refocus your own valuable time on the things that you need most – predictive analytics tailored to your business.

9. Conclusion

In their important little book[1] the authors reflect that "Historically, econometricians have favored other computing environments, some of which have fallen by the wayside and also a variety of packages with canned routines", they argue for the potential of R to solve econometric problems. With the support of REvolution computing R can be deployed as the Predictive Analytic layer in a production "mission critical", industrial-strength requirement (to use the IT clichés)! Kleiber and Zeileis (K&S) point out that in general in the simplest cases a function that performs exactly the type of predictive analytics required is already available. This subset of sometimes not so simple R Packages presented here; demonstrates that for the challenge of Economic Risk Capital estimation. As K&S point out further; utilization of R Packages makes your predictive analysis reproducible and applicable to new data sets. **REvolution Computing** in commercializing and industrializing the modeling process has brought a further innovative development to the technology available to support the modeling of Economic Risk Capital. REvolution puts Economic Risk Capital modeling into production.

9.1. Author and Review

AUTHOR: John A Morrison. John is a Predictive Analytics and large scale data management person, particularly in Financial Service, since he was in Asset Management in Edinburgh, when the Telex machine chuntered the Hong Kong closing prices around coffee time every morning. John lives for Financial Predictive Analytics; it's his hobby and his profession. John A Morrison is a Solution Architect in Risk Management. He is Director, Solution Partnerships of **Asymptotix** SA and an advisor to REvolution Computing. John has worked for IBM UK and SAP UK. He has advised, amongst others; HSBC, Lloyds, HBOS, Anglo Irish Bank, Prebon Marshall Yamane, UBS Warburg and Bank Vontobel. He trained at Deloitte and KPMG. His academic background is Monetary Econometrics.
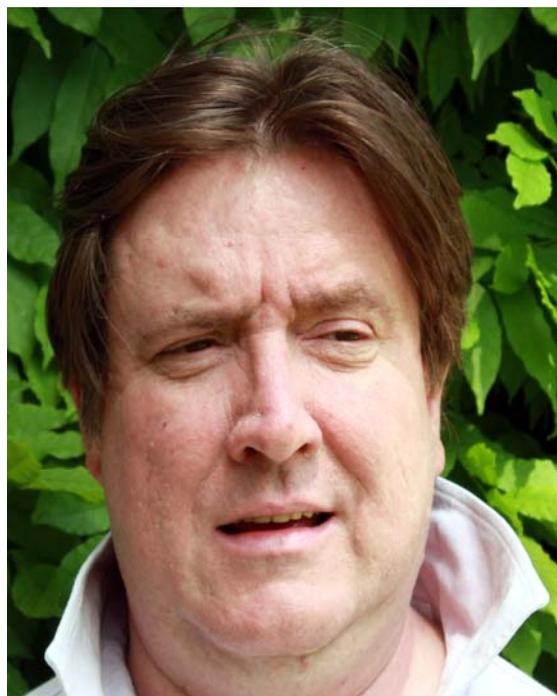
REVIEW: Colin Magee, Global Vice President, Bryan Lewis, Technical Director, **REvolution Computing**

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[1] "Applied Econometrics with R" by Christian Kleiber and Achim Zeilis, UseR, Springer; http://www.springer.com/economics/econometrics/book/978-0-387-77316-2