

R in Finance:

Using R in a commercial and highly regulated environment

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•Financial industry needs

- Talented IT and data-analysis experts
- •R provides
 - One of the most popular statistical programming languages
 - Wide academic support and training possibilities
 - Rmetrics: https://www.rmetrics.org/
 - New Course Series in DataCamp: Applied Finance with R
 - Coursera: Introduction to Computational Finance and Financial Econometrics
 - Active community and conferences
 - R/Finance 2016: Applied Finance with R *http://www.rinfinance.com/*
 - R in Insurance http://www.rininsurance.com/

Talent Pool and Support 2/2



| Language Types (click to hide) | | | | | | | | | | |
|--------------------------------|----------|----------|-------------------|---|------------------|--|--|--|--|--|
| Web [] | | D Mobile | Mobile Enterprise | | Embedded | | | | | |
| Lan | guage Ra | ank 7 | Types | | Spectrum Ranking | | | | | |
| 1. | С | | | - | 100.0 | | | | | |
| 2. | Java | 6 | | F | 98.1 | | | | | |
| 3. | Python | 6 | | F | 98.0 | | | | | |
| 4. | C++ | | | | 95.9 | | | | | |
| 5. | R | | Ę | 7 | 87.9 | | | | | |
| 6. | C# | ¢ | | 7 | 86.7 | | | | | |
| 7. | Ruby | ¢ | | Ţ | 74.5 | | | | | |
| 8. | Go | ¢ | | F | 71.9 | | | | | |
| 9. | Swift | | | - | 70.1 | | | | | |
| 10. | Matlab | | Ę | F | 68.5 | | | | | |

http://spectrum.ieee.org/static/interactive-the-top-programming-languages-2016



- Financial industry needs
 - Powerful and efficient data manipulation utilities
- R provides
 - Several advanced and intuitive packages, S3 and S4 class systems
 - require(dplyr)
 - require(data.table)
 - require(reshape2), require(plyr)
 - require(bigmemory)
 - require(R6)
 - In-memory and file-based data-storage integration
 - rhdf5 (Bioconductor)
 - require(RH2)



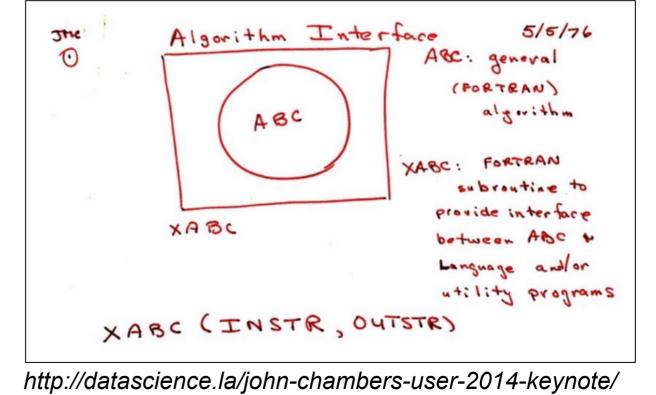
- Financial industry needs
 - Domain-specific packages
- R provides
 - Several packages for finance and insurance industry
 - require(PerformanceAnalytics)
 - require(quantmod), require(copula), require(evd)
 - require(ChainLadder)
 - require(MRMR), require(actuar)
 - require(zoo), require(xts), require(seasonal)
 - require(lifecontingencies)
 - require(RQuantLib)
 - CRAN Task View: Empirical Finance
 - https://cran.r-project.org/web/views/Finance.html

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- •Financial industry needs
 - Flexible and extensive integration capabilities to existing IT-environments

"The original concept for R was to create an interface language. [...] So the idea was to create a language that was really good at providing interfaces to other computing systems."

> John Chambers Keynote speech UseR 2014







- Reading different data formats
 - Tabular
 - read.table(file = "myfile")
 - require(XLConnect)
 - require(foreign)
 - Hierarchical (XML, HTML, JSON)
 - require(jsonlite)
 - Relational
 - require(DBI)
 - require(RJDBC)
 - Distributed:
 - require(SparkR)
 - require(sparklyr)
- Packages connecting to financial data providers
 - require(quantmod) (Yahoo Finance, Oanda, Google Finance)
 - require(Quandl)
 - require(Rblpapi) (Bloomberg)
 - require(rdatastream) (Thomson Reuters)





- Financial industry needs
 - Computational power to handle
 - Granular, large data sets / simulations
 - Speed to build reactive applications / prototypes
- R provides
 - Running C++ from R
 - Rcpp family of packages *http://www.rcpp.org/*
 - require(rTRNG)
 - Profiling
 - require(profvis), require(microbenchmark)
 - Big data interface with Spark
 - require(SparkR)
 - require(sparklyr)

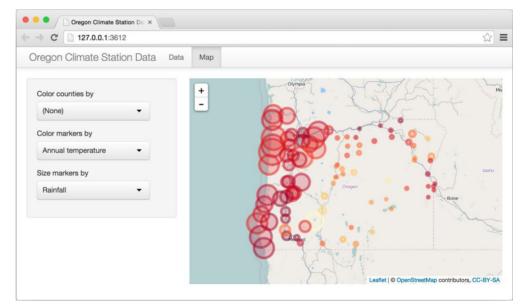


•Financial industry needs

- powerful and clear data visualization
- quick prototyping of models

•R provides

- require(ggplot2)
- require(ggvis)
- require(sp)
- require(Shiny)
- require(manipulate)
- require(plotly)
- require(animation)



www.htmlwidgets.org



- Financial industry needs
 - To meet regulatory and audit requirements
 - Data traceability
 - Extensive testing
 - Documentation
- R provides
 - require(packrat)
 - require(RUnit)
 - require(testthat)
 - require(covr)
 - require(roxygen2)
 - require(rmarkdown)
 - require(knitr)

Beyond Base R



As code increases...

- Source control
- Testing (unit, component, regression etc.)
- · Automated build servers
- Continuous integration and deployment
- Package and version management

As teams grow...

- Development methodology (e.g. SCRUM)
- Issue-tracking and project management
- Training and on-boarding
- Software engineering clean modular code
- Knowledge sharing team collaboration

R

As computation scales...

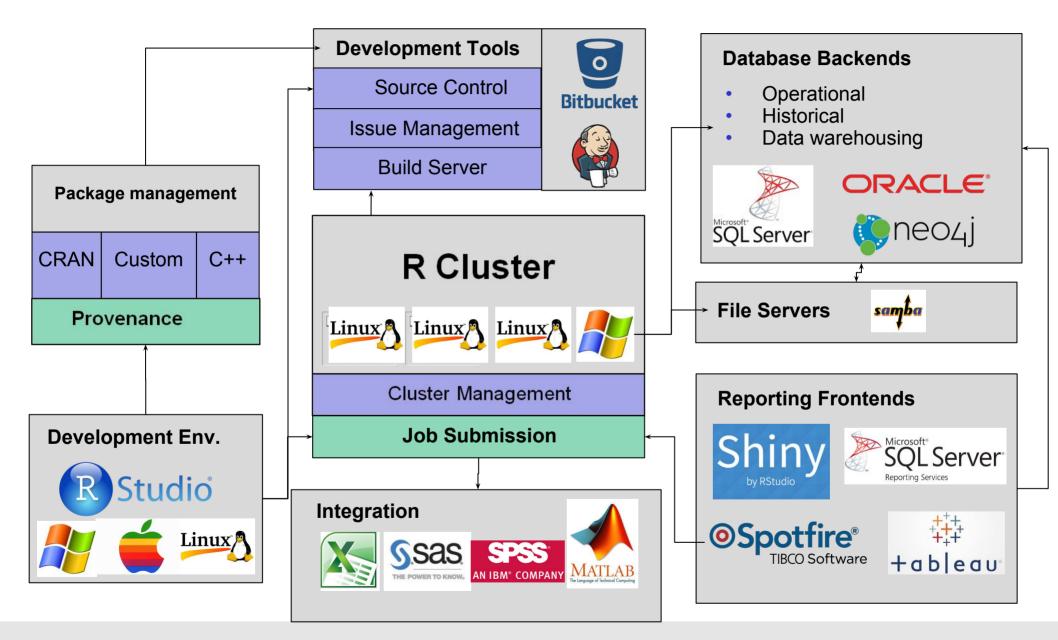
- Shared computational servers
- C++ for low-level computation Rcpp
- Customized execution environments
- Virtualization infrastructure as code
- Parallelization Spark
- Data storage, persistence

As usage diversifies...

- Integration with Excel, SAS, Python
- Reporting platforms Shiny, Spotfire
- Consistent cross-platform experience
- Alternative development platforms: R Notebooks, Shiny

Integrating R in an Enterprise Environment





Mirai Solutions – Projects in R



| Economic Capital Models / | Group-wide Risk Modeling Platform with R | Standard Formula Approach (EIOPA) | ORSA enhancements for Solvency II (e.g. pension risk, risk margin) | | Profit & Loss attributio n | Static and dynamic reporting for external stakeholders | |
|---------------------------------|---|---|---|--|--|---|--|
| Solvency II | as the core analytics component | Risk aggreg. approaches (variance-covari ance, copulas) | Extreme scenario generatio and aggregati | o Dyn on ar reins | amic internal nd external urance effects | (ORSA, QRTs) and internal requirements | |
| General Insurance | General Insurance pricing models (property, liability) | Internal (stochastic) models for premium & reserve quantification (incl. prop. / non-prop. reinsurance contracts) | | Risk Based Return Measures (new & existing business, actuarial triangles) | | Reinsurance optimization | |
| Financial Risk | Replicating portfolio configuration and reporting | R analytics infrastructure for portfolio risk insight (inv | | escale Monte-Carlo simulation models for credit default and gration risk quantification estment credit, reinsurance , receivables, trade & surety) | | Group-wide derivatives and credit risk data and reporting platforms | |
| Life Insurance / Other | Stochastic models for life liability and life business risk quantification | Award-winr operational quantification (top-down sco approach | risk model enario | Risk Tolerance limits | sensitivi | c scenario modeling, ties, change analyses nt and correlation | |