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Next first steps -  
selected applications of R

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# Next first steps - selected applications of R

Thomas Hütter, Diplom-Betriebswirt

- Application developer, consultant, accidental DBA
- Worked at consultancies, ISVs, end user companies
- Speaker at SQL events around Europe
- SQL Server > 6.5, Dynamics Nav > 3.0, R > 3.1.2



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# Agenda

- Recap: the R ecosystem; a light-weight installation
- How to create dynamic T-SQL using R functions
- Visualizations in R based on shape files, choropleth techniques
- Applying Benford's law for analysis & fraud detection
- Round-up; resources; credits; Q&A



# Recap: The R ecosystem

- Programming language for statistical computing and visualization, widely used by statisticians, data miners, analysts, data scientists
- Created by **Ross Ihaka** and **Robert Gentleman**, Uni Auckland, in 1993 as an open source implementation of the (1970s) S language
- GNU project, maintained by the R Foundation for Statistical Computing, compiled builds for Mac OS, Linux, Windows, supported by R Consortium
- Extensible through user-created packages, > **13000** available at CRAN
- Commercial support, e.g. since 2007 by Revolution Analytics, acquired by Microsoft in 2015, now provide Microsoft R Open, R Server
- Support for R now in SQL Server, Power BI, Azure ML...  
IDEs: R.App, RStudio, MS R Tools for VisualStudio



# Recap: A light-weight installation

- Follow [www.swirlstats.com](http://www.swirlstats.com) -> „Learn“  
This works equally well for Windows, Mac and Linux
- Necessary: Get and install the R base system
- Recommended: Download and install the RStudio IDE
- Useful: check for updates
- Optional: Also install Swirl
- Let the fun begin! 😊
- Remember:  
`install.packages("packagename")` to download a new package  
`library(packagename)` to start using it





# Dynamic T-SQL: basics

The exact SQL statement is composed at runtime, because

- it depends on parameters or conditions
- which may be determined interactively or from data
- and can influence filtering, columns or even tables used

Different conditions result in different SQL statements

Pro & con: flexibility vs complexity / security (SQL injection)

► `Dynamic1`

- Packages used: DBI, ODBC



# Dynamic T-SQL and R: applied

- Microsoft Dynamics Nav database (multi-company), meaning:
- (almost) all > 1000 tables exist once per company
- Goal: aggregate sales data over all companies
- number of companies may change over time

► `Dynamic2`

Packages used: DBI, ODBC





# Visualizations in R based on shapefiles

What a shapefile is:

- open file format standard for handling geospatial vector data
- developed and maintained by GIS software vendor Esri
- actually „a shapefile" consists of 3 mandatory files:
  - ▶ `.shp` - shape format, the actual geo objects
  - ▶ `.shx` - shape index, to allow seeking forwards/backwards
  - ▶ `.dbf` - attributes/payload data for each shape (dBase IV format)
  - ▶ plus optional metadata files, projection, geocoding index...



# Visualizations in R based on shapefiles

Where to get shapefiles:

- all over the internet :-) e.g. government or open data organizations
- or even „roll your own“ using GIS software

What to do with them:

- visualize all kinds of data that are geo-related
- location of places, distribution of measures

► Shape1

Packages used: raster, rgeos, foreign



# Choropleth techniques

- A choropleth map is a thematic map in which areas are coloured/shaded/patterned depending on some measure to be analyzed
- Measures can be populations, election results, sales figures...
- Auto-shading using RColorBrewer, for sequential (light to dark), diverging (around mid-range) or qualitative (max. difference) palettes

► Shape2

Packages: GISTools(maptools, sp, RColorBrewer, rgeos), plyr, XML



# Benford's law: basics

- Aka „Newcomb-Benford-Law“ or „First-Digit-Law“
- Simon Newcomb 1881, credited to Frank Benford 1938  
(a fact which follows Stigler's law, discovered by Merton ;-)
- It's an observation about the distribution of leading digits in naturally occurring collections of numerical data
- Intuition: digits are evenly distributed
- Observed: In logarithm tables, the earlier pages were more worn
- Conclusion: leading digits are more likely to be small



# Benford's law: maths

- Evenly distributed digits:  
 $P = 1/9 \approx 0.1111$
- First digit  $D_1$  according to Benford:  
 $P(D_1=d) = \log_{10}(d+1) - \log_{10}(d)$   
 $= \log_{10}(1 + 1/d)$

Even more math on Benford:  
[en.wikipedia.org/wiki/Benford%27s\\_law](https://en.wikipedia.org/wiki/Benford%27s_law)

d	evenly	Benford
1	0.1111	0.3010
2	0.1111	0.1761
3	0.1111	0.1249
4	0.1111	0.0969
5	0.1111	0.0792
6	0.1111	0.0669
7	0.1111	0.0580
8	0.1111	0.0512
9	0.1111	0.0458



# Applying Benford's law

- Determine the data / measure to examine
- extract first digits, regardless of magnitude
- calculate the table of relative density
- compare to Benford's table
- visualize

► DemoBenford1+2

Packages: DBI, XML, ggplot2





# Round-up

## Dynamic SQL

- possible realization in R using apply functions
- know the blessings *and* the curse of your dynamic SQL

## Shapefiles & choropleth

- showing data relating to geographic instances
- keep data order, have a balanced colour / shading scheme

## Benford's law

- works for natural or transactional data, the bigger the better
- does not work for numbers influenced by human rules



# Resources on- and offline

- [www.swirlstats.com](http://www.swirlstats.com) „Learn R, in R“
- [www.r-project.org/](http://www.r-project.org/) -> Mirrors of CRAN = Comprehensive R Archive Network
- [www.sommarskog.se/dynamic\\_sql.html](http://www.sommarskog.se/dynamic_sql.html) The Curse and Blessings of Dynamic SQL
- [www.suche-postleitzahl.org/downloads](http://www.suche-postleitzahl.org/downloads) Shapefiles post codes Germany
- [www.geodatenzentrum.de](http://www.geodatenzentrum.de) Shapefiles federal states
- [www.mygeoposition.com](http://www.mygeoposition.com) Geocoding
- R Cookbook, Paul Teetor, O'Reilly, ISBN 978-0596809157
- R Graphics Cookbook, Winston Chang, O'Reilly, ISBN 978-1449316952
- Datendesign mit R, Thomas Rahlf, Open Source Press, (German) ISBN 978-3955390945, ~~Out of press - hurry!~~ now: Springer-Verlag



# Credits

## Data:

- [mbs.microsoft.com](https://mbs.microsoft.com) Cronus database
- [statisticstimes.com/index.php](https://statisticstimes.com/index.php) Country data (UN, Worldbank, IMF)
- [www.tankerkoenig.de](https://www.tankerkoenig.de) Base for „sales“ data (CC BY 4.0)

## Shape files:

- [www.suche-postleitzahl.org](https://www.suche-postleitzahl.org) (Open database license, © OpenStreetMap)
- [www.geodatenzentrum.de](https://www.geodatenzentrum.de) GeoBasis-DE / BKG 2016
- [thematicmapping.org](https://thematicmapping.org) Bjørn Sandvik (CC Attribution-Share Alike)
- [www.imergis.nl](https://www.imergis.nl) BRK Kadaster Nederland (CC BY)

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# Next first steps - selected applications of R

Time for some Q & A:

That is: questions that might be of common interest,  
and their answers might fit into the remaining time :-)



# Next first steps - selected applications of R

Thank you for your interest & keep in touch:

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This file and all demo scripts can be found at:

<https://github.com/SQLThomas/Conferences/tree/master/SQLGla2018>

