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Calling External Routines in Stata

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Motivation

- Stata allows to call **external routines**, written in other software, to perform specific tasks within Stata
- This talk offers some insights on how to develop a **Stata ADO file** embedding an external software routine (R, in this case)
- We provide a user-written Stata module **stree**, written to allow users to run regression trees (a Machine Learning technique currently unavailable in Stata) by calling back the R software

TStat

Three "R ==> Stata" alternatives

Rcall
Integrating R with Stata by allowing inter-process communication between the two software (Haghish, E.F., 2017)

← Very flexible, but a bit time-consuming to learn

Rsource
For running an R source program from an inline sequence of lines or from a file, in batch mode from within Stata

← Very easy to use, but not really handy for ADO files

shell
Allowing to send commands to your operating system or to enter your operating system for interactive use

← More general approach, apparently more complicated, but finally easy to use

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The Basics of Decision Trees

Decision trees can be applied to both regression and classification problems

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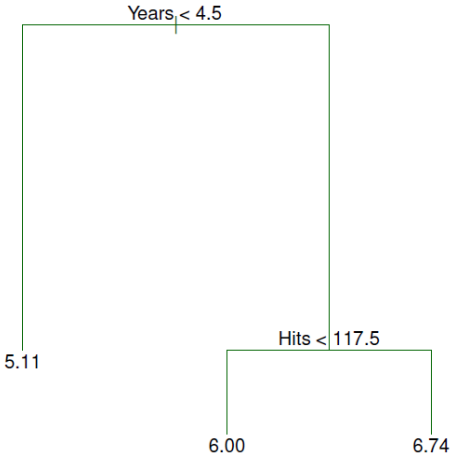
Example of a Decision Tree



- For the Hitters data, a regression tree for predicting the log salary of a baseball player, based on the number of years that he has played in the major leagues and the number of hits that he made in the previous year.
- At a given internal node, the label (of the form $X_j < t_k$) indicates the left-hand branch emanating from that split, and the right-hand branch corresponds to $X_j \geq t_k$. For instance, the split at the top of the tree results in two large branches. The left-hand branch corresponds to `Years`<4.5, and the right-hand branch corresponds to `Years`>=4.5.
- The tree has two internal nodes and three terminal nodes, or leaves. The number in each leaf is the mean of the response for the observations that fall there.

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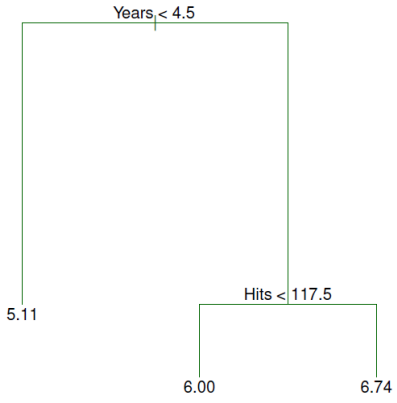
Interpretation of Results

`Years` is the most important factor in determining `Salary`, and players with less experience earn lower salaries than more experienced players.

> Given that a player is less experienced, the number of `Hits` that he made in the previous year seems to play little role in his `Salary`.

But among players who have been in the major leagues for five or more years, the number of `Hits` made in the previous year does affect `Salary`, and players who made more `Hits` last year tend to have higher salaries.



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Finding the optimal number of terminal nodes: Optimal-Tree detection

As other Machine Learning methods facing a bias-variance trade-off, the **optimal tree** is the one "balancing" *bias reduction* and *variance increase*, within the *largest* possible tree T_0 obtained from the *training* dataset.

The problem can be solved via a **penalization** approach, which penalizes too complex trees by at the same time allowing a not too large bias

This can be done via **optimal tree-pruning**

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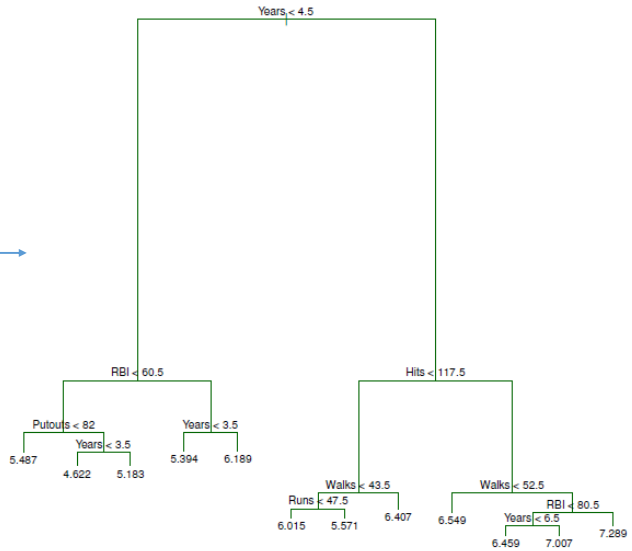
Example - Regression tree for the Hitters data 1

This is the **unpruned tree** that results from top-down greedy splitting on the training data.



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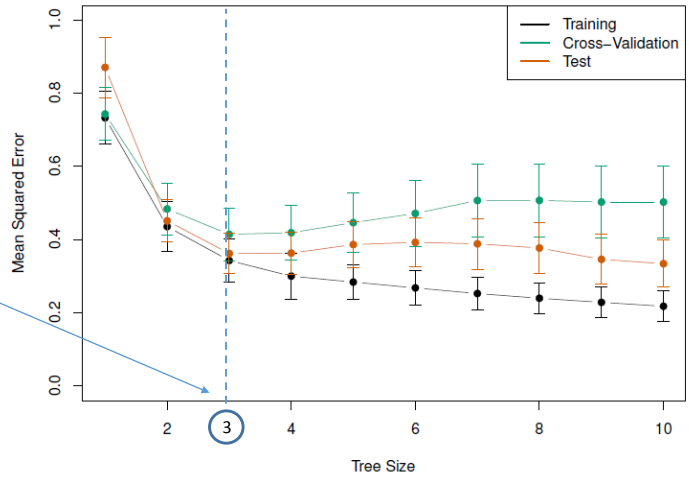
Example - Regression tree for the Hitters data 2

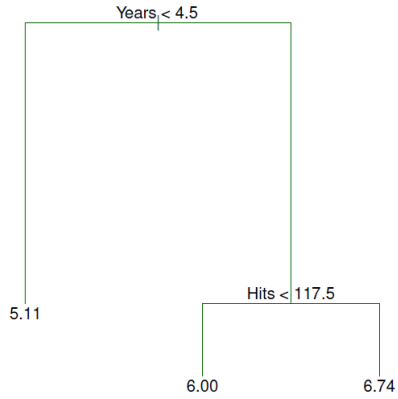
The **minimum cross-validation error** occurs at a tree size of **3** nodes



MSE for the **training**, the **cross-validation**, and the **test** as a function of the **number of terminal nodes** in the pruned tree.

Example - Regression tree for the Hitters data 3

3-node **optimal** tree



A Stata/R user-written ADO-file template

1. Write **`srprog.ado`**, a master Stata program calling back Stata sub-programs containing R code

2. Write **`srprog1.ado, srprog2.ado,...`** the needed Stata sub-programs containing R code and generating an R program called **`srprog.R`**

3. Write the Stata program **`runR.ado`** executing **`srprog.R`** via the **`shell`** Stata command

A Stata/R user-written ADO-file template – step 1

Write a Stata program called **`srprog`**

Set the main directory as the present working directory (`pwd`)

Export the ".dta" dataset in the current memory into a ".csv" called "mydata.csv"

Run a program **`srprog1`** containing an R script conditionally on `option1`

Execute the Stata command **`runR`** to make Stata able to let R to do its job.

```
*************************************************************************
capture program drop srprog
program define srprog
      syntax [something] [if] [in] [weights] , options
*************************************************************************
      local dir `c(pwd)'
      cd "`dir'"
*************************************************************************
      qui export delimited `var' using "mydata.csv", nolabel replace
*************************************************************************
      if "`option1'" != ""{
      srprog1 , options     // Stata program containing an R script
*************************************************************************
      runR , options       // Stata program running R
*************************************************************************
end
```

A Stata/R user-written ADO-file template – step 2

1. Program called `srprog1`
2. Generate an R script called `srprog.R`
3. Write the R code instead of `...`

```
*********************************************************************
capture program drop srprog1
*********************************************************************
program srprog1  // this does the most extended tree (baseline)
syntax ,
// Write R Code
quietly: file open rcode using srprog.R, write replace
quietly: file write rcode ///
    `"..."' _newline ///
    `"..."'
quietly: file close rcode
end
```


A Stata/R user-written ADO-file template – step 3

1. Stata program runR
2. Put the R program srprog.R into a local
3. Choose the operating system
4. Stata **shell** command to run **srprog.R**

```
*********************************************************************
capture program drop runR
*********************************************************************
program define runR
syntax , op_sys(string)
*********************************************************************
// Run R from Stata
*********************************************************************
local using `"srprog.R"'
*********************************************************************
* MAC
if "`op_sys'"=="IOS"{
local rpath    `"/Library/Frameworks/R.framework/Resources/bin/R"'
local roptions `"--slave"'
}
*********************************************************************
* PC
else if "`op_sys'"=="WIN"{
local rpath `"C:\Program Files\R\R-3.2.1\bin\x64\Rterm.exe"'
local roptions `"--vanilla"'
}
*********************************************************************
tempfile tempsource templis
copy `"`using'"' `"`tempsource'"'
local Rcommand `""`rpath'" `roptions' < "`tempsource'" > "`templis'""'
shell `Rcommand'
*********************************************************************
// Type R output in Stata
*********************************************************************
disp _n as text "--> Beginning of R output from source file: " as result `"`using'"'
type `"`templis'"'
disp _n as text "--> End of R output from source file: " as result `"`using'"'
*********************************************************************
end
*********************************************************************
```

The Stata user-written command stree

```
stree [anything] [if] [in] [weights] , model(modeltype)
      op_sys(ostype) [prune(integer) cv_tree]
```

Options

model(*modeltype*) specifies the type of model, where:

modeltype	
tree	Fits a tree, either unpruned, pruned, and optimal via CV
tree_rf	Fits a tree using *random forests*
tree_bag	Fits a tree using *bagging*
tree_boost	Fits a tree using the *boosting algorithm*

op_sys(*ostype*) specifies the operating system you are working with. Two options for ostype are available, "WIN" (Windows) and "IOS" (MAC)

prune(*integer*) specifies the optimal pruned tree at size (number of nodes) "integer"; for instance prune(5), prune(8), ...

cv_tree specifies to run "cross-validation" in order to determine the optimal tree size

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Application to a classification tree (using sctree*)

```
* SET THE DIRECTORY
*cd "/Users/giocer/Dropbox/Giovanni/R/R_Cerulli/R into Stata/inout" // MAC
cd "C:\Users\Cerulli\Dropbox\Giovanni\R\R_Cerulli\R into Stata\inout" // PC

* LOAD THE DATASET
use carseats , clear

* TRANFORM ALL THE "FACTOR-VARIABLES" INTO "STRINGS" FOR R TO READ THEM
global y "High"
global VARS "High US Urban ShelveLoc"
foreach V of global VARS{
decode `V' , gen(`V'2)
drop `V'
rename `V'2 `V'
}

* SET THE OUTCOME, THE COVARIATES, AND THE PRUNING SIZE
global y "High"
global xvars "CompPrice Income Advertising Population Price Age Education US Urban ShelveLoc"
global M=6 // pruning size

* ESTIMATE THE CLASSIFICATION TREE
*sctree $y $xvars  , model(tree) op_sys(WIN)              // only overal classification tree + train-MSE
sctree $y $xvars  , model(tree) op_sys(WIN) prune($M)     // only tree of size M + train-MSE + test-MSE
*sctree $y $xvars  , model(tree) op_sys(WIN) cv_tree      // cross-validation with optimal tree size
```

* For fitting a **regression tree** the companion command is called **srtree**

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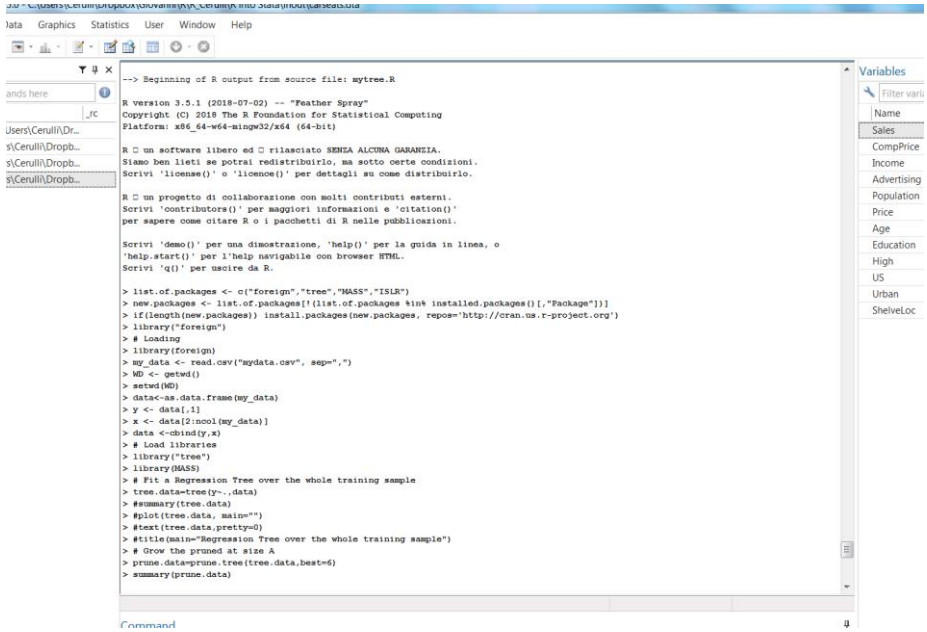
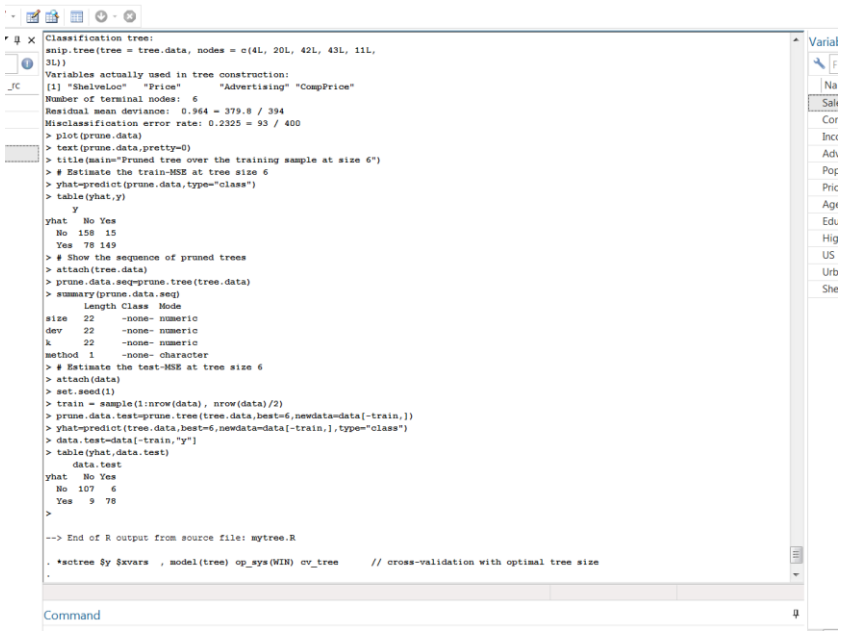
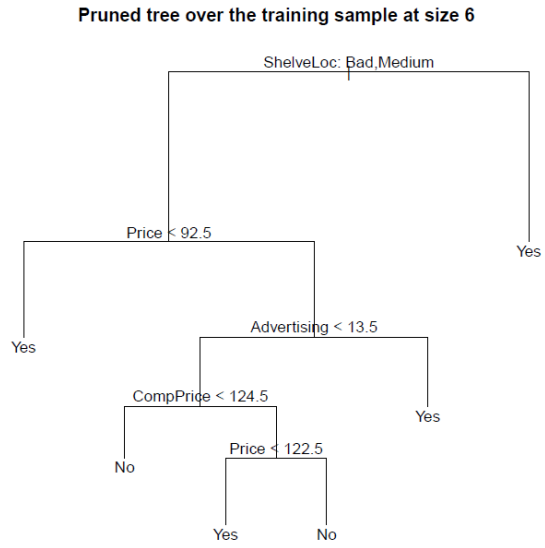
R output visible as Stata output - 1



R output visible as Stata output - 2

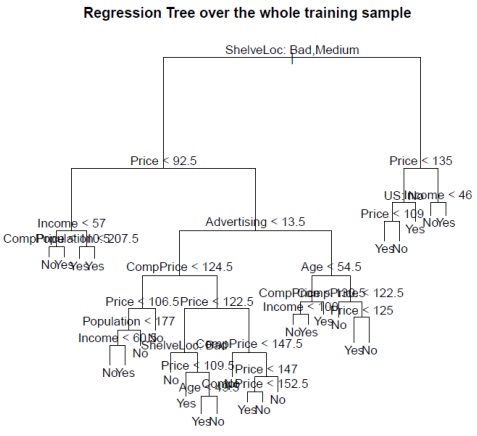


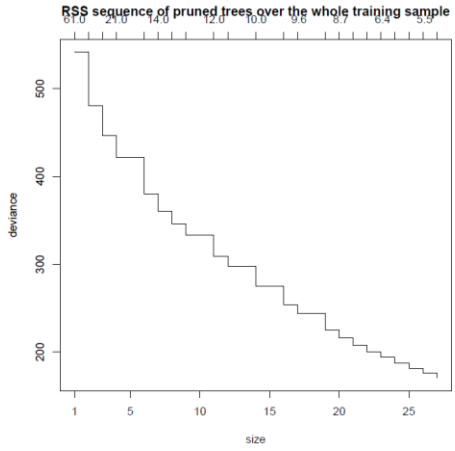
R output visible as Stata output - 3



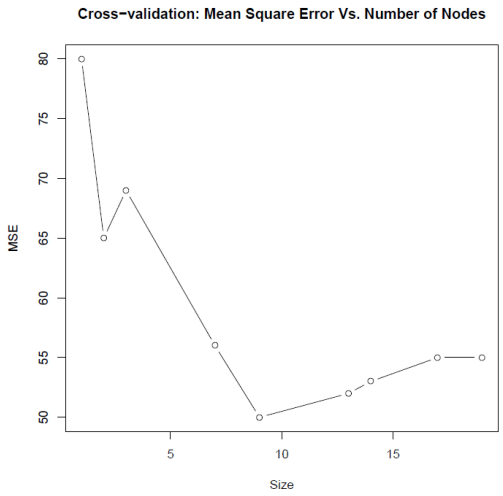
Optimal tree size via cross-validation - 1

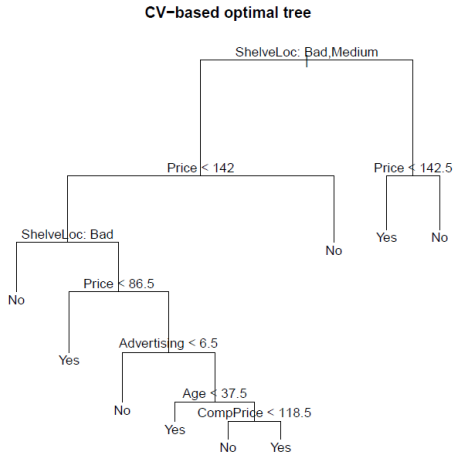
```
sctree $y $xvars , model(tree) op_sys(WIN) cv_tree
```





Optimal tree size via cross-validation - 2





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Thanks for your attention

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