Using \texttt{car} Functions in Other Functions

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\textbf{Abstract}

The \texttt{car} package (Fox and Weisberg, 2011) provides many functions that are applied to a fitted regression model, perform additional calculations on the model or possibly compute a different model, and then return values and graphs. In some cases, users may wish to write functions that call functions in \texttt{car} for a particular purpose. Because of the scoping rules used in R, several functions in \texttt{car} that work when called from the command prompt may fail when called inside another function. We discuss how users can modify their programs to avoid this problem.

\section{ncvTest}

The function \texttt{ncvTest} (Fox and Weisberg, 2011, Sec. 6.5.2) computes tests for non-constant variance in linear models as a function of the mean, the default, or any other linear function of regressors, even for regressors not part of the mean function. For example,

\begin{verbatim}
library(car)
m2 <- lm(prestige ~ education, Prestige)
ncvTest(m2, ~ income)
\end{verbatim}

Non-constant Variance Score Test
Variance formula: ~ income
Chisquare = 1.521, Df = 1, p = 0.22

fits \texttt{prestige} as a linear function of \texttt{education}, and tests for nonconstant variance as a function of \texttt{income}, another regressor in the data set \texttt{Prestige}. Embedding this in a function fails:

\begin{verbatim}
f3 <- function(meanmod, dta, varmod) {
  m3 <- lm(meanmod, dta)
  ncvTest(m3, varmod)
}
f3(prestige ~ education, Prestige, ~ income)
\end{verbatim}

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Error in is.data.frame(data) : object 'dta' not found

In this case the model m3 is defined in the environment of the function, and the argument dta is defined in the global environment, and is therefore invisible when ncvTest is called. A solution is to copy dta to the global environment.

\[
f4 <- function(meanmod, dta, varmod) {
  assign(".dta", dta, envir=.GlobalEnv)
  assign(".meanmod", meanmod, envir=.GlobalEnv)
  m1 <- lm(.meanmod, .dta)
  ans <- ncvTest(m1, varmod)
  remove(".dta", envir=.GlobalEnv)
  remove(".meanmod", envir=.GlobalEnv)
  ans
}
\]

f4(prestige ~ education, Prestige, ~income)

Non-constant Variance Score Test
Variance formula: ~ income
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f4(prestige ~ education, Prestige, ~income)

Non-constant Variance Score Test
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The assign function copies the dta and meanmod arguments to the global environment where ncvTest will be evaluated, and the remove function removes them before exiting the function. This is an inherently problematic strategy, because an object assigned in the global environment will replace an existing object of the same name. Consequently we renamed the dta argument .dta, with an initial period, but this is not a guarantee that there was no preexisting object with this name.

This same method can be used with functions in the effects package. Suppose, for example, you want to write a function that will fit a model, provide printed summaries and also draw a effects plot. The following function will fail:

\[
\text{library(effects)}
\]
\[
f <- function(dta, formula, terms) {
  print(m1 <- lm(formula, .dta))
  Effect(terms, m1)
}
\]
\[
\text{form <- prestige ~ income*type + education}
\]
\[
\text{terms <- c("income", "type")}
\]
\[
f(Duncan, form, terms)
\]

As with ncvTest, dta will not be in the correct environment when Effect is evaluated. The solution is to copy dta to the global environment:
library(effects)
fc.working <- function(dta, formula, terms) {
  assign(".dta", dta, env=.GlobalEnv)
  print(m1 <- lm(formula, .dta))
  Effect(terms, m1)
  remove(".dta", envir=.GlobalEnv)
}
fc.working(Duncan, form, terms)

Assigning formula to the global environment is not necessary here because it is
used by lm but not by Effect.

2 Boot

The Boot function in car provides a convenience front-end for the function
boot in the boot package (Canty and Ripley, 2013; Fox and Weisberg, 2012).
With no arguments beyond the name of a regression object and the number of
replications R, Boot creates the proper arguments for boot for case resampling
bootstraps, and returns the coefficient vector for each sample:

\[
m1 <- lm(\text{time} \sim \text{t1} + \text{t2}, \text{Transact})
\]
\[
b1 <- \text{Boot}(m1, R=999)
\]
\[
\text{summary(b1)}
\]

Number of bootstrap replications \(R = 999\)

<table>
<thead>
<tr>
<th></th>
<th>original</th>
<th>bootBias</th>
<th>bootSE</th>
<th>bootMed</th>
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<td>190.03</td>
<td>133.84</td>
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<tr>
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<td>0.021723</td>
<td>0.67</td>
<td>5.50</td>
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<tr>
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<td>2.03</td>
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<td>0.15</td>
<td>2.04</td>
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The returned object b1 is of class "boot", as are objects created directly from
the boot function, so helper functions in the boot package and in car can be
used on these objects, e.g.,

confint(b1)

Bootstrap bca confidence intervals

<table>
<thead>
<tr>
<th></th>
<th>2.5 %</th>
<th>97.5 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>-217.722</td>
<td>522.464</td>
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<tr>
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<td>6.544</td>
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<tr>
<td>t2</td>
<td>1.764</td>
<td>2.365</td>
</tr>
</tbody>
</table>

The Boot function would have scoping problems even without the user embed-
dding it in a function because the boot function called by Boot tries to evaluate
the model defined in the global environment in a local environment. In car
we define an environment
.carEnv <- new.env(parent=emptyenv())

and then evaluate the model in the environment .carEnv. This environment is not exported, so to see that it exists you would need to enter car:::.carEnv. We use this same trick in the Boot.default function so that .carEnv is globally visible. Here is a copy of Boot.default to show how this works.

Boot.default <- function(object, f=coef, labels=names(coef(object)),
                        R=999, method=c("case", "residual")) {
  if(!(require(boot))) stop("The 'boot' package is missing")
  f0 <- f(object)
  if(length(labels) != length(f0)) labels <- paste("V", seq(length(f0)), sep="")
  method <- match.arg(method)
  if(method="case") {
    boot.f <- function(data, indices, .fn) {
      assign(".boot.indices", indices, envir=car:::.carEnv)
      mod <- update(object, subset=get(".boot.indices", envir=car:::.carEnv))
      if(mod$qr$rank != object$qr$rank){
        out <- .fn(object)
        out <- rep(NA, length(out)) } else {out <- .fn(mod)}
      out
    }
  } else {
    boot.f <- function(data, indices, .fn) {
      first <- all(indices == seq(length(indices)))
      res <- if(first) object$residuals else
              residuals(object, type="pearson")[seq(ranks(indices))]/sqrt(1 - hatvalues(object))
      val <- fitted(object) + res[indices]
      if (!is.null(object$na.action)){
        pad <- object$na.action
        attr(pad, "class") <- "exclude"
        val <- naresid(pad, val)
      }
      assign(".y.boot", val, envir=car:::.carEnv)
      mod <- update(object, get(".y.boot", envir=car:::.carEnv) ~ .)
      if(mod$qr$rank != object$qr$rank){
        out <- .fn(object)
        out <- rep(NA, length(out)) } else {out <- .fn(mod)}
      out
    }
  }
  b <- boot(data.frame(update(object, model=TRUE)$model), boot.f, R, .fn=f)
  colnames(b$$t) <- labels
  if(exists(".y.boot", envir=car:::.carEnv))
    remove(".y.boot", envir=car:::.carEnv)
  if(exists(".boot.indices", envir=car:::.carEnv))

remove(".boot.indices", envir=car:::.carEnv)

The was also fixed in `bootCase`.

References

Angelo Canty and Brian Ripley. boot: Bootstrap R (S-Plus) functions. R package version 1.3-9, 2013.
