4: Linear Models

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Ideas and issues illustrated by the graphs in this vignette

The graphs shown here relate to issues that arise in the use of the linear model fitting function `lm()`.

Note: The version of Figure 4.13 that is shown in Section 2 is for a random subset of 80 of the 158 rows of the dataset `Electricity`.[1]

1 Code for Functions that Plot the Figures

```
fig4.1 <-
function (){
    size10 <- list(fontsize=list(text=8, points=6))
    print(round(cor(nihills), 2))
    splom(nihills, par.settings=size10)
}
```

```
fig4.2 <-
function ()
{
    size10 <- list(fontsize=list(text=10, points=6))
    lognihills <- log(nihills[,1:4])
    names(lognihills) <- c("ldist", "lclim", "ltim", "ltimf")
    print(round(cor(lognihills), 2))
    vnam <- paste("log(", names(nihills)[1:4], ")", sep="")
    splom(lognihills, pscales=0, varnames=vnam, par.settings=size10)
}
```

[1] Display of the figures can be suppressed, when processing this vignette through *knitr*, by placing an object `doFigs=FALSE` in the workspace.

```
fig4.3 <-
function (obj=lognigrad.lm, mfrow=c(1,2))
{
    objtxt <- deparse(substitute(obj))
    if(!exists(objtxt))stop(paste("Requires argument obj =", objtxt))
    opar <- par(mfrow=mfrow)
    termplot(obj, col.term="gray", partial=TRUE,
             col.res="black", smooth=panel.smooth)
    par(opar)
}
```

```
fig4.4 <-
function (obj=lognigrad.lm, mfrow=c(1,4)){
    objtxt <- deparse(substitute(obj))
    if(!exists(objtxt))stop(paste("Requires argument obj =", objtxt))
    opar <- par(mfrow=mfrow, pty="s",
                mgp=c(2.25,.5,0), mar=c(3.6,3.6,2.1,0.6))
    plot(obj, cex.lab=1.4)
    par(opar)
}
```

```
fig4.5 <-
function (obj=lognigrad.lm, mfrow=c(1,4), nsim=10){
    opar <- par(mfrow=mfrow, mgp=c(2.25,.5,0), pty="s",
                mar=c(3.6,3.6, 2.1, 0.6))
    objtxt <- deparse(substitute(obj))
    if(!exists(objtxt))stop(paste("Requires argument obj =", objtxt))
    y <- simulate(obj, nsim=nsim)
    ## Look only at the first simulation
    lognisim1.lm <- lm(y[, 1] ~ ldist + lgradient, data=lognihills)
    plot(lognisim1.lm, cex.lab=1.1, cex.caption=0.75)
    par(opar)
    invisible(y)
}
```

```
fig4.6 <-
function (obj=lognigrad.lm2)
{
    objtxt <- deparse(substitute(obj))
    if(!exists(objtxt))stop(paste("Requires argument obj =", objtxt))
    opar <- par(mfrow=c(1,4), mgp=c(2.25,.5,0), pty="s",
                mar=c(3.6,3.6, 2.1, 0.6))
```

```
    plot(obj, cex.lab=1.1, cex.caption=0.8)
    par(opar)
}
```

```
fig4.7 <-
function (obj=lognigrad.lm)
{
    objtxt <- deparse(substitute(obj))
    if(!exists(objtxt))stop(paste("Requires argument obj =", objtxt))
    ## The following generates a matrix of 23 rows (observations)
    ## by 1000 sets of simulated responses
    simlogniY <- simulate(obj, nsim=1000)
    ## Extract the QR decomposition of the model matrix
    qr <- obj$qr
    ## For each column of simlogniY, calculate regression coefficients
    bmat <- qr.coef(qr, simlogniY)
    bDF <- as.data.frame(t(bmat))
    names(bDF) <- c("Intercept", "coef_logdist", "coef_lgradient")
    gph <- densityplot(~Intercept+coef_logdist+coef_lgradient, data=bDF,
                       outer=TRUE, scales="free", plot.points=NA,
                       panel=function(x, ...){
                           panel.densityplot(x, ...)
                           ci <- quantile(x, c(.025, .975))
                           panel.abline(v=ci, col="gray")
                       }
                       )
    gph
}
```

```
fig4.8 <-
function (plotit=TRUE)
{
library(DAAG)
with(rice, interaction.plot(x.factor=fert,
                            trace.factor=variety,
                            ShootDryMass,
                            cex.lab=1.2, xpd=TRUE))
}
```

```
fig4.9 <-
function (plotit=TRUE)
{
```

```
    ## Panel A
    gph <- xyplot(tempDiff ~ vapPress, groups=CO2level, data = leaftemp,
                  ylab="", aspect=1,
                  cex.main=0.75,
                  par.settings=simpleTheme(pch=c(2,1,6), cex=0.85,
                                           lty=1:3))
    hat1 <- predict(lm(tempDiff ~ vapPress, data = leaftemp))
    hat2 <- predict(lm(tempDiff ~ vapPress + CO2level, data = leaftemp))
    hat3 <- predict(lm(tempDiff ~ vapPress * CO2level, data = leaftemp))
    hat123 <- data.frame(hat1=hat1, hat2=hat2, hat3=hat3)
    gph1 <- gph+latticeExtra::layer(panel.xyplot(x, hat1, type="l",
                                                 col.line=1, ...),
                      data=hat123)
    ## Panel B
    gph2 <- gph+latticeExtra::layer(panel.xyplot(x, hat2, type="l", ...),
                      data=hat123)
    ## Panel C
    gph3 <- gph+latticeExtra::layer(panel.xyplot(x, hat3, type="l", ...),
                      data=hat123)
    maintxt <- c(as.call(~ vapPress),
                 as.call(~ vapPress + CO2level),
                 as.call(~ vapPress*CO2level))
    gph1 <- update(gph1, main=deparse(maintxt[[1]]), ylab="tempDiff",
                   auto.key=list(text=c("low","med","high"),
                                 between=1, between.columns=2,
                                 columns=3))
    gph2 <- update(gph2, main=deparse(maintxt[[2]]),
                   auto.key=list(text=c("low","med","high"),
                                 between=1, between.columns=2,
                                 columns=3))
    gph3 <- update(gph3, main=deparse(maintxt[[3]]),
                   auto.key=list(text=c("low","med","high"),
                                 between=1, between.columns=2,
                                 columns=3))
    if(plotit){
        print(gph1, position=c(0,0,.36,1))
        print(gph2, position=c(0.34,0,.68,1), newpage=FALSE)
        print(gph3, position=c(0.66,0,1,1), newpage=FALSE)
    }
    invisible(list(gph1, gph2, gph3))
}
```

```
fig4.10 <-
function ()
```

```
{
if(!require(sp, quietly=TRUE)){
print("Package 'sp' must be available")
return()
}
data(meuse, package="sp"); data(meuse.riv, package="sp")
coordinates(meuse) <- ~ x + y
gph <- bubble(meuse, "lead", pch=1, maxsize=2,
              main = list("Lead(ppm)", fontface="plain", cex=1.35),
              key.entries =  100 * 2^(0:4), col=c(2,4),
              scales=list(axes=TRUE, tck=0.4))
add <- latticeExtra::layer(panel.lines(meuse.riv[,1], meuse.riv[,2],
                           col="gray"))
gph+add
}
```

```
fig4.11 <-
function ()
{
    if(!exists('meuse'))stop("Dataset 'meuse' must be available")
    opar <- par(cex=1.25, mar=rep(1.5,4))
    if(!require(car))
        stop("Package 'car' must be installed")
    spm(~ lead+elev+dist+jitter(unclass(ffreq)) | soil,
        col=adjustcolor(rep("black",3), alpha.f=0.5),
        var.labels=c("lead","elev","dist","jitter(ffreq)"),
        data=meuse, cex.labels=1.5, reg.line=NA)
    par(opar)
}
```

```
fig4.12 <-
function ()
{
    if(!exists('meuse'))stop("Dataset 'meuse' must be available")
    if(!require(car))
        stop("Package 'car' must be installed")
    meuse$ffreq <- factor(meuse$ffreq)
    meuse$soil <- factor(meuse$soil)
    meuse.lm <- lm(log(lead) ~ elev + dist + ffreq + soil, data=meuse)
    opar <- par(mfrow=c(1,4), mar=c(3.1,3.1,2.6,0.6))
    termplot(meuse.lm, partial=TRUE, smooth=panel.smooth)
    par(opar)
}
```

```
fig4.13 <-
function (data=Electricity)
{
    if(!require(car))stop("Package 'car' must be installed")
    spm(data, smooth=TRUE, reg.line=NA, cex.labels=1.5,
        col=adjustcolor(rep("black",3), alpha.f=0.4))
}
```

```
fig4.14 <-
function (data=log(Electricity[,1:2]), varlabs = c("log(cost)", "log(q)"))
{
    if(!require(car))stop("Package 'car' must be installed")
    spm(data, var.labels=varlabs, smooth=TRUE, reg.line=NA,
    col=adjustcolor(rep("black",3), alpha.f=0.5))
}
```

```
fig4.15 <-
function (obj=elec.lm, mfrow=c(2,4))
{
    opar <- par(mfrow=mfrow, mar=c(3.1,3.1,1.6,0.6), mgp=c(2,0.5,0))
    termplot(obj, partial=T, smooth=panel.smooth)
    par(opar)
}
```

```
fig4.16 <-
function (obj=elec2xx.lm, mfrow=c(1,4)){
    opar <- par(mfrow=mfrow, mgp=c(2.25,.5,0), pty="s",
                mar=c(3.6,3.6, 2.1, 0.6))
    plot(obj, cex.lab=1.1, cex.caption=0.75)
    par(opar)
}
```

```
fig4.17 <-
function (){
    set.seed(37)   # Use to reproduce graph that is shown
    bsnVaryNvar(m=100, nvar=3:50, nvmax=3)
}
```

2 Show the Figures

Unless `doFigs` is found in the workspace and is `FALSE`, then subject to checks that all necessary datasets and packages are available, the figures are now shown.

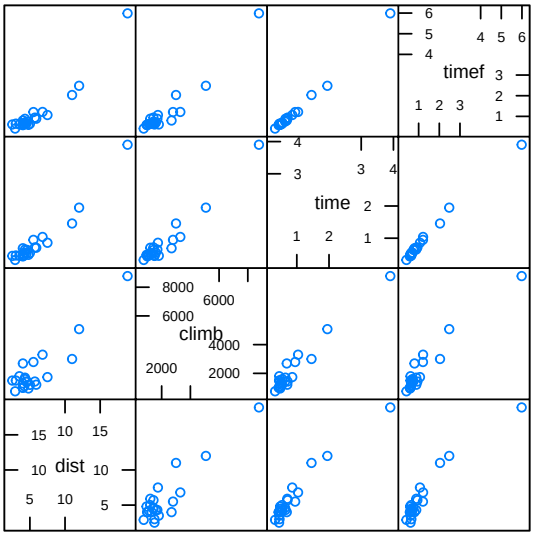
```
if(!exists("doFigs")) doFigs <- TRUE
```

```
pkgs <- c("DAAG","sp","splines","car","leaps","sp","quantreg")
z <- sapply(pkgs, require, character.only=TRUE, warn.conflicts=FALSE)
if(any(!z)){
  notAvail <- paste(names(z)[!z], collapse=", ")
  print(paste("The following packages should be installed:", notAvail))
}
```

```
if(!exists("Electricity")){
  getElec <- try(data("Electricity", package="Ecdat"))
  if(getElec != "Electricity") print("Dataset 'Electricity' is not available")
}
```

```
if(doFigs)fig4.1()
```

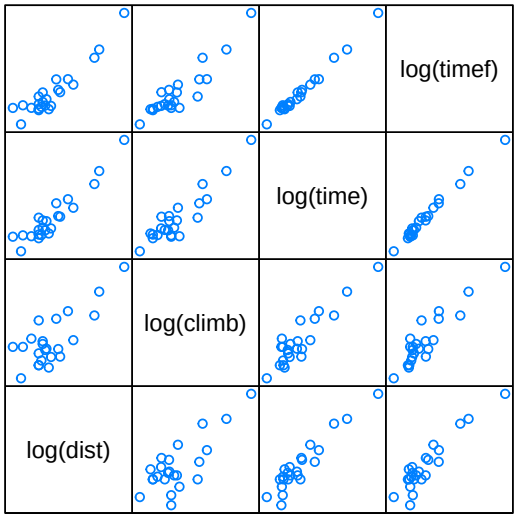
```
      dist climb time timef
dist  1.00  0.91 0.97  0.95
climb 0.91  1.00 0.97  0.96
time  0.97  0.97 1.00  1.00
timef 0.95  0.96 1.00  1.00
```



Scatter Plot Matrix

```
if(doFigs)fig4.2()
```

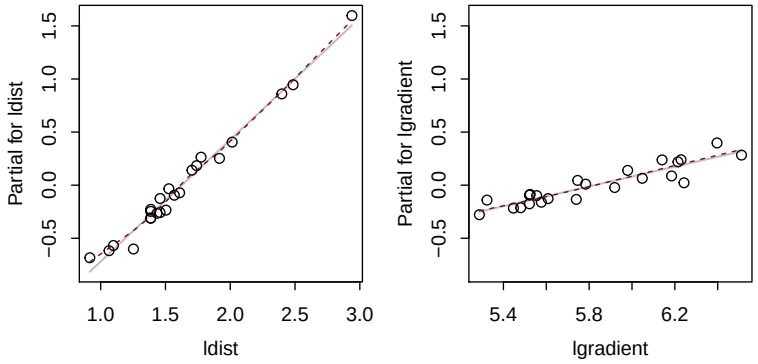
```
      ldist lclim ltim ltimf
ldist  1.00  0.78 0.95  0.93
lclim  0.78  1.00 0.92  0.92
ltim   0.95  0.92 1.00  0.99
ltimf  0.93  0.92 0.99  1.00
```



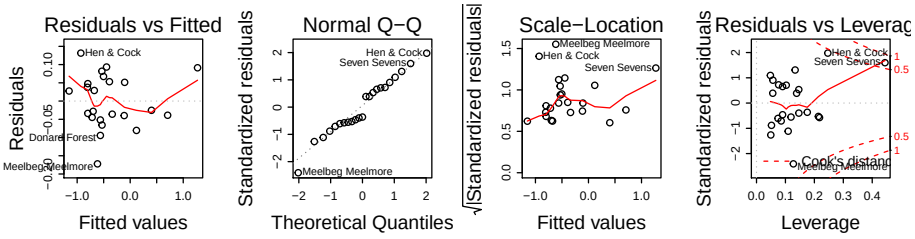
Scatter Plot Matrix

```
nihills[,"gradient"] <- with(nihills, climb/dist)
lognihills <- log(nihills)
names(lognihills) <- paste("l", names(nihills), sep="")
lognigrad.lm <- lm(ltime ~ ldist + lgradient, data=lognihills)
lognigrad.lm2 <- lm(ltime ~ poly(ldist, 2, raw=TRUE) + lgradient,
                    data=lognihills)
```

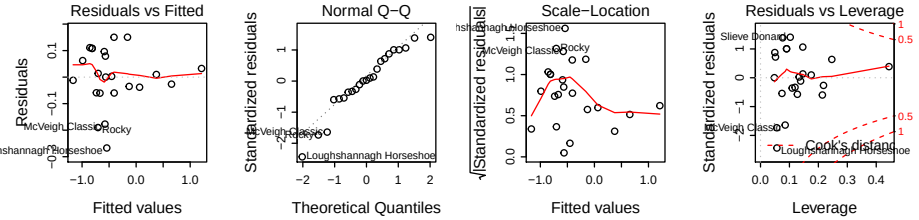
```
if(doFigs)fig4.3()
```



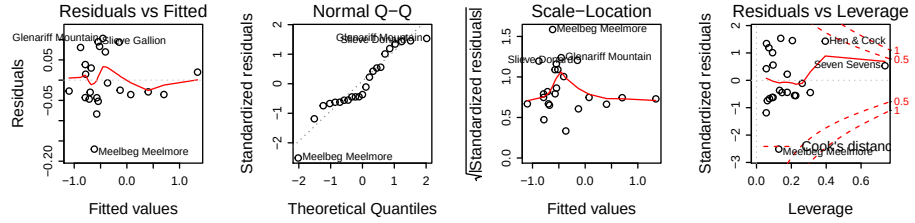

```
if(doFigs)fig4.4()
```



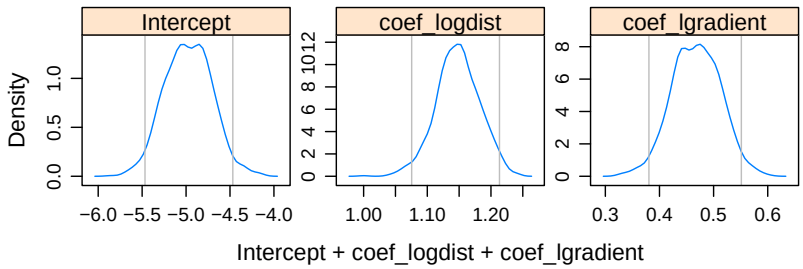

```
if(doFigs)fig4.5()
```



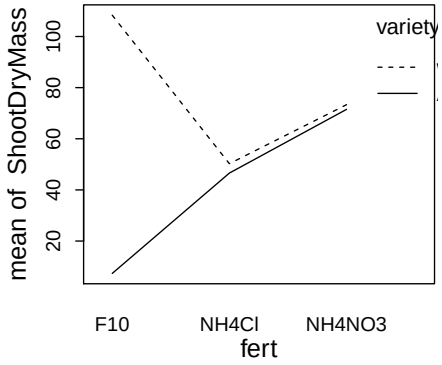

```
if(doFigs)fig4.6()
```



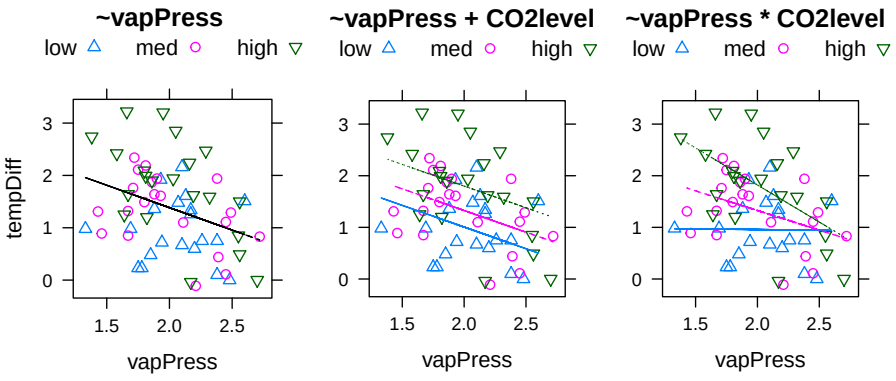
```
if(doFigs)fig4.7()
```



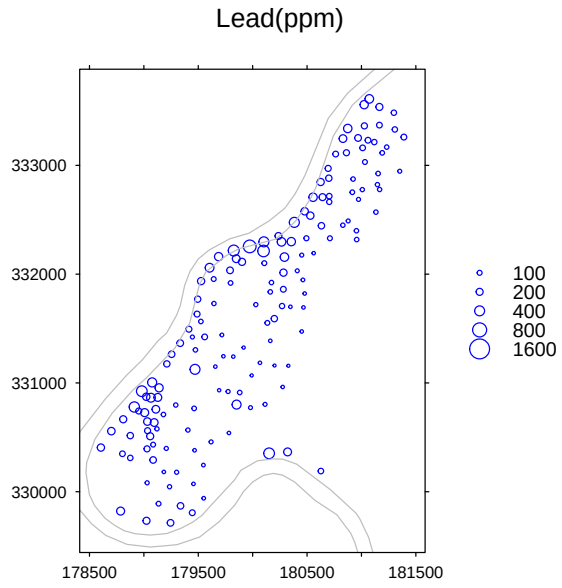

```
if(doFigs)fig4.8()
```



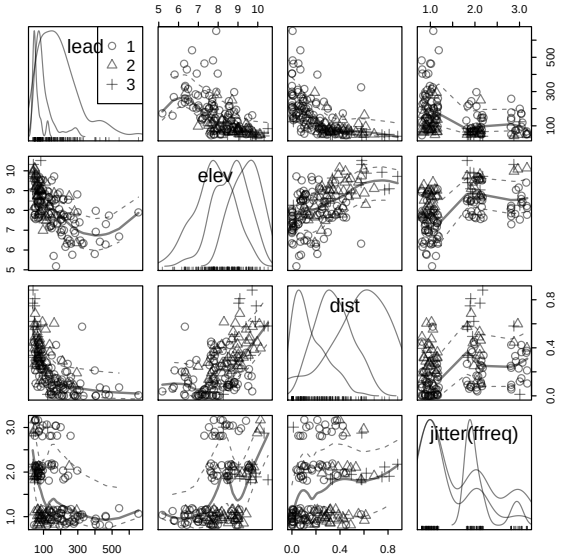

```
if(doFigs)fig4.9()
```



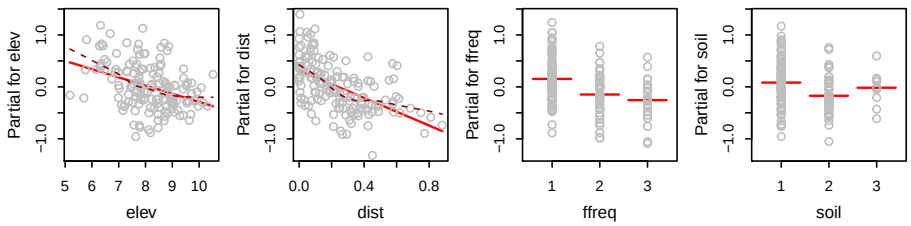
```
if(doFigs)if(require(sp)) fig4.10() else print("Required package 'sp' is not available")
```



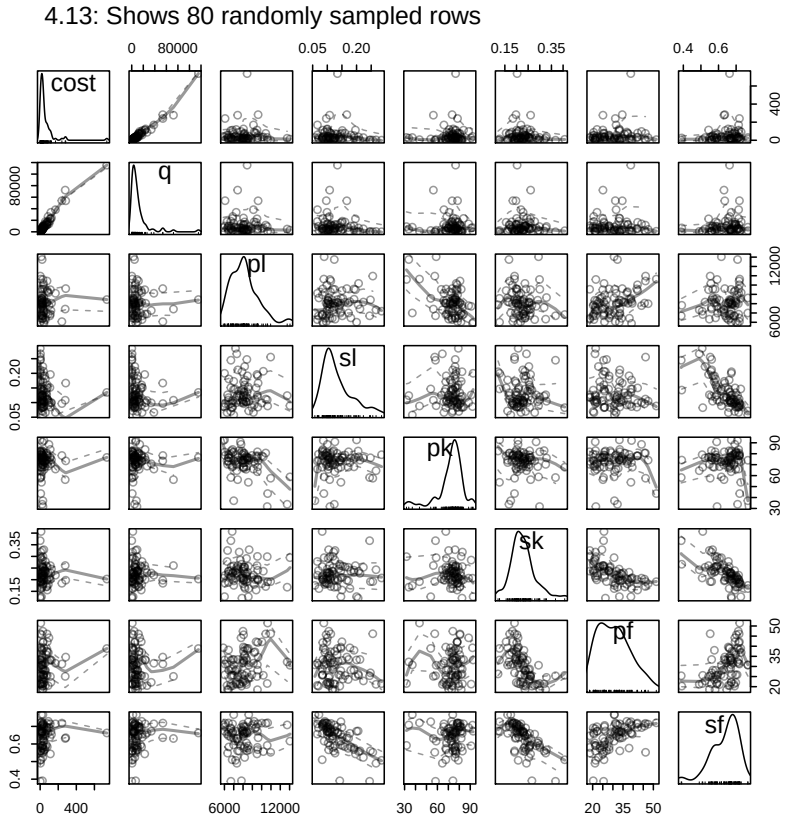

```
if(doFigs)fig4.11()
```



```
if(doFigs)fig4.12()
```

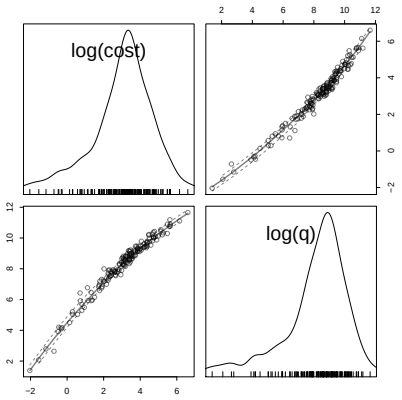



```
if(doFigs)if(!exists("Electricity")) print("Dataset 'Electricity' is not available") else {
nsamp80 <- sample(nrow(Electricity),80)
fig4.13(data=Electricity[nsamp80, ])
mtext(side=3,line=2, paste("4.13: Shows 80 randomly sampled rows"), adj=0)
}
```

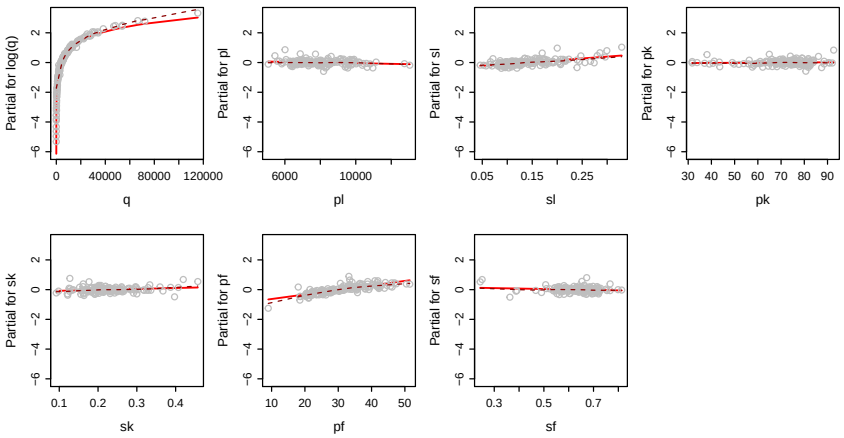


```
if(exists("Electricity")){
elec.lm <- lm(log(cost) ~ log(q)+pl+sl+pk+sk+pf+sf, data=Electricity)
elec2xx.lm <- lm(log(cost) ~ log(q) * (pl + sl) + pf, data = Electricity)
}
```

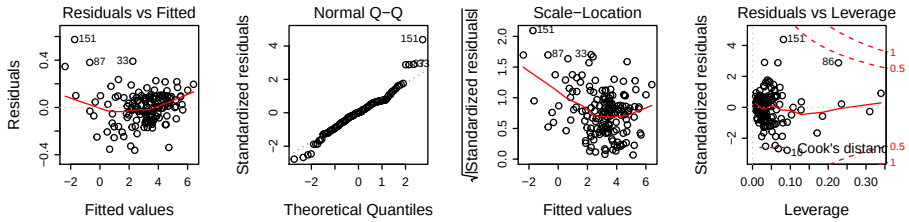
```
if(doFigs)if(exists("Electricity"))fig4.14()
```




```
if(doFigs)if(exists("Electricity"))fig4.15()
```




```
if(doFigs)if(exists("Electricity"))fig4.16()
```




```
if(doFigs)if(require(DAAG)) fig4.17()
```