

# Package ‘MPV’

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**Title** Data Sets from Montgomery, Peck and Vining

**Version** 1.55

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**Description** Most of this package consists of data sets from the textbook Introduction to Linear Regression Analysis (3rd ed), by Montgomery, Peck and Vining. Some additional data sets and functions related to visualization of linear and nonparametric regression results are included.

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BiasVarPlot	<i>Local Polynomial Bias and Variability</i>
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## Description

Graphs of confidence interval estimates for bias and standard deviation of in local polynomial regression curve estimates.

## Usage

```
BiasVarPlot(data, k1=1, k2=2, h, h2, output=FALSE, g, layout=TRUE)
```

## Arguments

data	A data frame, whose first column must be the explanatory variable and whose second column must be the response variable.
k1	degree of local polynomial used in curve estimator.
k2	degree of local polynomial used in bias estimator.

h	bandwidth for regression estimator.
h2	bandwidth for bias estimator.
output	if true, numeric output is printed to the console window.
g	the target function, if known (for use in simulations).
layout	if true, a 2x1 layout of plots is sent to the graphics device.

**Value**

A list containing the confidence interval limits, pointwise estimates of bias, standard deviation of bias, curve estimate, standard deviation of curve estimate, and approximate confidence limits for curve estimates. Graphs of the curve estimate confidence limits and the bias confidence limits.

**Author(s)**

W. John Braun and Wenkai Ma

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BioOxyDemand	<i>Biochemical Oxygen Demand</i>
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---

**Description**

The BioOxyDemand data frame has 14 rows and 2 columns.

**Usage**

```
data(BioOxyDemand)
```

**Format**

This data frame contains the following columns:

**x** a numeric vector

**y** a numeric vector

**Source**

Devore, J. L. (2000) *Probability and Statistics for Engineering and the Sciences (5th ed)*, Duxbury

**Examples**

```
plot(BioOxyDemand)
summary(lm(y ~ x, data = BioOxyDemand))
```

---

cement	<i>Cement Data</i>
--------	--------------------

---

**Description**

The cement data frame has 13 rows and 5 columns.

**Usage**

```
data(cement)
```

**Format**

This data frame contains the following columns:

**y** a numeric vector

**x1** a numeric vector

**x2** a numeric vector

**x3** a numeric vector

**x4** a numeric vector

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(cement)
pairs(cement)
```

---

cigbutts	<i>Cigarette Butts</i>
----------	------------------------

---

**Description**

On a university campus there are a number of areas designated for smoking. Outside of those areas, smoking is not permitted. One of the smoking areas is towards the north end of the campus near some parking lots and a large walkway towards one of the residences. Along the walkway, cigarette butts are visible in the nearby grass. Numbers of cigarette butts were counted at various distances from the smoking area in 200x80 square-cm quadrats located just west of the walkway.

**Usage**

```
data("cigbutts")
```

**Format**

A data frame with 15 observations on the following 2 variables.

distance distance from gazebo

count observed number of butts

---

 GANOVA

*Graphical ANOVA Plot*


---

**Description**

Graphical analysis of one-way ANOVA data. It allows visualization of the usual F-test.

**Usage**

```
GANOVA(dataset, var.equal=TRUE, type="QQ", center=TRUE, shift=0)
```

**Arguments**

dataset	A data frame, whose first column must be the factor variable and whose second column must be the response variable.
var.equal	Logical: if TRUE, within-sample variances are assumed to be equal
type	"QQ" or "hist"
center	if TRUE, center and scale the means to match the scale of the errors
shift	on the histogram, lift the points representing the means above the horizontal axis by this amount.

**Value**

A QQ-plot or a histogram and rugplot

**Author(s)**

W. John Braun and Sarah MacQueen

**Source**

Braun, W.J. 2013. Naive Analysis of Variance. Journal of Statistics Education.

---

`gasdata`*Natural Gas Consumption in a Single-Family Residence*

---

**Description**

This data frame contains the average monthly volume of natural gas used in the furnace of a 1600 square foot house located in London, Ontario, for each month from 2006 until 2011. It also contains the average temperature for each month, and a measure of degree days. Insulation was added to the roof on one occasions, the walls were insulated on a second occasion, and the mid-efficiency furnace was replaced with a high-efficiency furnace on a third occasion.

**Usage**

```
data("gasdata")
```

**Format**

A data frame with 70 observations on the following 9 variables.

month numeric 1=January, 12=December

degreedays numeric, Celsius

cubicmetres total volume of gas used in a month

dailyusage average amount of gas used per day

temp average temperature in Celsius

year numeric

I1 indicator that roof insulation is present

I2 indicator that wall insulation is present

I3 indicator that high efficiency furnace is present

---

`GFplot`*Graphical F Plot for Significance in Regression*

---

**Description**

This function analyzes regression data graphically. It allows visualization of the usual F-test for significance of regression.

**Usage**

```
GFplot(X, y, plotIt=TRUE, sortTrt=FALSE, type="hist", includeIntercept=TRUE, labels=FALSE)
```

**Arguments**

<code>X</code>	The design matrix.
<code>y</code>	A numeric vector containing the response.
<code>plotIt</code>	Logical: if TRUE, a graph is drawn.
<code>sortTrt</code>	Logical: if TRUE, an attempt is made at sorting the predictor effects in descending order.
<code>type</code>	"QQ" or "hist"
<code>includeIntercept</code>	Logical: if TRUE, the intercept effect is plotted; otherwise, it is omitted from the plot.
<code>labels</code>	logical: if TRUE, names of predictor variables are used as labels; otherwise, the design matrix column numbers are used as labels

**Value**

A QQ-plot or a histogram and rugplot, or a list if `plotIt=FALSE`

**Author(s)**

W. John Braun

**Source**

Braun, W.J. 2013. Regression Analysis and the QR Decomposition. Preprint.

**Examples**

```
# Example 1
X <- p4.18[,-4]
y <- p4.18[,4]
GFplot(X, y, type="hist", includeIntercept=FALSE)
title("Evidence of Regression in the Jojoba Oil Data")
# Example 2
set.seed(4571)
Z <- matrix(rnorm(400), ncol=10)
A <- matrix(rnorm(81), ncol=9)
simdata <- data.frame(Z[,1], crossprod(t(Z[, -1]), A))
names(simdata) <- c("y", paste("x", 1:9, sep=""))
GFplot(simdata[, -1], simdata[, 1], type="hist", includeIntercept=FALSE)
title("Evidence of Regression in Simulated Data Set")
# Example 3
GFplot(table.b1[, -1], table.b1[, 1], type="hist", includeIntercept=FALSE)
title("Evidence of Regression in NFL Data Set")
# An example where stepwise AIC selects the complement
# of the set of variables that are actually in the true model:
X <- pathoeg[,-10]
y <- pathoeg[,10]
par(mfrow=c(2,2))
GFplot(X, y)
```



```
Gfplot(X, y, sortTrt=TRUE)
Gfplot(X, y, type="QQ")
Gfplot(X, y, sortTrt=TRUE, type="QQ")
X <- table.b1[, -1] # NFL data
y <- table.b1[, 1]
Gfplot(X, y)
```

---

GRegplot

*Graphical Regression Plot*

---

### Description

This function analyzes regression data graphically. It allows visualization of the usual F-test for significance of regression.

### Usage

```
GRegplot(X, y, sortTrt=FALSE, includeIntercept=TRUE, type="hist")
```

### Arguments

X	The design matrix.
y	A numeric vector containing the response.
sortTrt	Logical: if TRUE, an attempt is made at sorting the predictor effects in descending order.
includeIntercept	Logical: if TRUE, the intercept effect is plotted; otherwise, it is omitted from the plot.
type	Character: hist, for histogram; dot, for stripchart

### Value

A histogram or dotplot and rugplot

### Author(s)

W. John Braun

### Source

Braun, W.J. 2014. Visualization of Evidence in Regression Analysis with the QR Decomposition. Preprint.

**Examples**

```

# Example 1
X <- p4.18[,-4]
y <- p4.18[,4]
GRegplot(X, y, includeIntercept=FALSE)
title("Evidence of Regression in the Jojoba Oil Data")
# Example 2
set.seed(4571)
Z <- matrix(rnorm(400), ncol=10)
A <- matrix(rnorm(81), ncol=9)
simdata <- data.frame(Z[,1], crossprod(t(Z[, -1]),A))
names(simdata) <- c("y", paste("x", 1:9, sep=""))
GRegplot(simdata[, -1], simdata[,1], includeIntercept=FALSE)
title("Evidence of Regression in Simulated Data Set")
# Example 3
GRegplot(table.b1[, -1], table.b1[,1], includeIntercept=FALSE)
title("Evidence of Regression in NFL Data Set")
# An example where stepwise AIC selects the complement
# of the set of variables that are actually in the true model:
X <- pathoeg[,-10]
y <- pathoeg[,10]
par(mfrow=c(2,1))
GRegplot(X, y)
GRegplot(X, y, sortTrt=TRUE)
X <- table.b1[, -1] # NFL data
y <- table.b1[,1]
GRegplot(X, y)

```

---

Juliet

*Juliet*


---

**Description**

Juliet has 28 rows and 9 columns. The data is of the input and output of the Spirit Still "Juliet" from Endless Summer Distillery. It is suggested to split the data by the Batch factor for ease of use.

**Usage**

```
Juliet
```

**Format**

The data frame contains the following 9 columns.

Batch a Factor determining how many times the volume has been through the still.

Vol1 Volume in litres, initial

P1 Percent alcohol present, initial

LAA1 Litres Absolute Alcohol initial, Vol1\*P1

Vol2 Volume in litres, final  
 P2 Percent alcohol present, final  
 LAA2 Litres Absolute Alcohol final, Vol2\*P2  
 Yield Percent yield obtained, LAA2/LAA1  
 Date Character, Date of run

### Details

The purpose of this information is to determine the optimal initial volume and percentage. The information is broken down by Batch. A batch factor 1 means that it is the first time the liquid has gone through the spirit still. The first run through the still should have the most loss due to the "heads" and "tails". Literature states that the first run through a spirit still should yield 70 percent. A batch factor 2 means that it is the second time the liquid has gone through the spirit still. A batch factor 3 means that it is the third time or more that the liquid has gone through the spirit still. Each subsequent distillation should result in a higher yield, never to exceed 95 percent.

### Source

Charisse Woods, Endless Summer Distillery, (2015).

### Examples

```
summary(Juliet)

#Split apart the Batch factor for easier use.
juliet<-split(Juliet,Juliet$Batch)
juliet1<-juliet$'1'
juliet2<-juliet$'2'
juliet3<-juliet$'3'

plot(LAA1~LAA2,data=Juliet)
plot(LAA1~LAA2,data=juliet1)
```

### Description

Confidence interval estimates for bias in local polynomial regression.

### Usage

```
LPBias(xy,k1,k2,h,h2,numgrid=401,alpha=.95)
```

**Arguments**

xy	A data frame, whose first column must be the explanatory variable and whose second column must be the response variable.
k1	degree of local polynomial used in curve estimator.
k2	degree of local polynomial used in bias estimator.
h	bandwidth for regression estimator.
h2	bandwidth for bias estimator.
numgrid	number of gridpoints used in the curve estimator.
alpha	nominal confidence level.

**Value**

A list containing the confidence interval limits, pointwise estimates of bias, standard deviation of bias, curve estimate, standard deviation of curve estimate, and approximate confidence limits for curve estimates.

**Author(s)**

W. John Braun and Wenkai Ma

---

motor

*Motor Vibration Data*

---

**Description**

Noise measurements for 5 samples of motors, each sample based on a different brand of bearing.

**Usage**

```
data("motor")
```

**Format**

A data frame with 5 columns.

Brand 1 A numeric vector length 6

Brand 2 A numeric vector length 6

Brand 3 A numeric vector length 6

Brand 4 A numeric vector length 6

Brand 5 A numeric vector length 6

**Source**

Devore, J. and N. Farnum (2005) Applied Statistics for Engineers and Scientists. Thomson.

---

noisyimage	<i>noisy image</i>
------------	--------------------

---

**Description**

The noisyimage is a list. The third component is noisy version of the third component of [tarimage](#).

**Usage**

```
data(noisyimage)
```

**Format**

This list contains the following elements:

**x** a numeric vector having 101 elements.

**y** a numeric vector having 101 elements.

**xy** a numeric matrix having 101 rows and columns

**Examples**

```
with(noisyimage, image(x, y, xy))
```

---

oldwash	<i>oldwash</i>
---------	----------------

---

**Description**

The oldwash dataframe has 49 rows and 8 columns. The data are from the start up of a wash still considering the amount of time it takes to heat up to a specified temperature and possible influencing factors.

**Usage**

```
data("oldwash")
```

**Format**

A data frame with 49 observations on the following 8 variables.

Date character, the date of the run

startT degrees Celsius, numeric, initial temperature

endT degrees Celsius, numeric, final temperature

time in minutes, numeric, amount of time to reach final temperature

Vol in litres, numeric, amount of liquid in the tank (max 2000L)

alc numeric, the percentage of alcohol present in the liquid

who character, relates to the person who ran the still

batch factor with levels 1 = first time through, 2 = second time through

**Details**

The purpose of the wash still is to increase the percentage of alcohol and strip out unwanted particulate. It can take a long time to heat up and this can lead to problems in meeting production time limits.

**Source**

Charisse Woods, Endless Summer Distillery (2014)

**Examples**

```
oldwash.lm<-lm(log(time)~startT+endT+Vol+alc+who+batch,data=oldwash)
summary(oldwash.lm)
par(mfrow=c(2,2))
plot(oldwash.lm)

data2<-subset(oldwash,batch==2)
hist(data2$time)
data1<-subset(oldwash,batch==1)
hist(data1$time)

oldwash.lmc<-lm(time~startT+endT+Vol+alc+who+batch,data=data1)
summary(oldwash.lmc)
plot(oldwash.lmc)

oldwash.lmd<-lm(time~startT+endT+Vol+alc+who+batch,data=data2)
summary(oldwash.lmd)
plot(oldwash.lmd)
```

---

p11.12

*Data For Problem 11-12*

---

**Description**

The p11.12 data frame has 19 observations on satellite cost.

**Usage**

```
data(p11.12)
```

**Format**

This data frame contains the following columns:

**cost** first-unit satellite cost

**x** weight of the electronics suite

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**References**

Simpson and Montgomery (1998)

**Examples**

```
data(p11.12)
attach(p11.12)
plot(cost~x)
detach(p11.12)
```

---

p11.15

*Data set for Problem 11-15*

---

**Description**

The p11.15 data frame has 9 rows and 2 columns.

**Usage**

```
data(p11.15)
```

**Format**

This data frame contains the following columns:

**x** a numeric vector

**y** a numeric vector

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**References**

Ryan (1997), Stefanski (1991)

**Examples**

```
data(p11.15)
plot(p11.15)
attach(p11.15)
lines(lowess(x,y))
detach(p11.15)
```

---

p12.11

*Data Set for Problem 12-11*

---

**Description**

The p12.11 data frame has 44 observations on the fraction of active chlorine in a chemical product as a function of time after manufacturing.

**Usage**

```
data(p12.11)
```

**Format**

This data frame contains the following columns:

**xi** time

**yi** available chlorine

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p12.11)
plot(p12.11)
lines(lowess(p12.11))
```

---

p12.12

*Data Set for Problem 12-12*

---

**Description**

The p12.12 data frame has 18 observations on an chemical experiment. A nonlinear model relating concentration to reaction time and temperature with an additive error is proposed to fit these data.

**Usage**

```
data(p12.12)
```



**Format**

This data frame contains the following columns:

- x1** reaction time (in minutes)
- x2** temperature (in degrees Celsius)
- y** concentration (in grams/liter)

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p12.12)
attach(p12.12)
# fitting the linearized model
logy.lm <- lm(I(log(y))~I(log(x1))+I(log(x2)))
summary(logy.lm)
plot(logy.lm, which=1) # checking the residuals
# fitting the nonlinear model
y.nls <- nls(y ~ theta1*I(x1^theta2)*I(x2^theta3), start=list(theta1=.95,
theta2=.76, theta3=.21))
summary(y.nls)
plot(resid(y.nls)~fitted(y.nls)) # checking the residuals
```

---

p12.8

*Data Set for Problem 12-8*

---

**Description**

The p12.8 data frame has 14 rows and 2 columns.

**Usage**

```
data(p12.8)
```

**Format**

This data frame contains the following columns:

- x** a numeric vector
- y** a numeric vector

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p12.8)
```

---

p13.1

*Data Set for Problem 13-1*

---

**Description**

The p13.1 data frame has 25 observation on the test-firing results for surface-to-air missiles.

**Usage**

```
data(p13.1)
```

**Format**

This data frame contains the following columns:

**x** target speed (in Knots)

**y** hit (=1) or miss (=0)

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p13.1)
```

---

p13.16

*Data Set for Problem 13-16*

---

**Description**

The p13.16 data frame has 16 rows and 5 columns.

**Usage**

```
data(p13.16)
```

**Format**

This data frame contains the following columns:

**X1** a numeric vector

**X2** a numeric vector

**X3** a numeric vector

**X4** a numeric vector

**Y** a numeric vector

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p13.16)
```

---

p13.2

*Data Set for Problem 13-2*

---

**Description**

The p13.2 data frame has 20 observations on home ownership.

**Usage**

```
data(p13.2)
```

**Format**

This data frame contains the following columns:

**x** family income

**y** home ownership (1 = yes, 0 = no)

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p13.2)
```

---

p13.20

*Data Set for Problem 13-20*

---

**Description**

The p13.20 data frame has 30 rows and 2 columns.

**Usage**

```
data(p13.20)
```

**Format**

This data frame contains the following columns:

**yhat** a numeric vector

**resdev** a numeric vector

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p13.20)
```

---

p13.3

*Data Set for Problem 13-3*

---

**Description**

The p13.3 data frame has 10 observations on the compressive strength of an alloy fastener used in aircraft construction.

**Usage**

```
data(p13.3)
```

**Format**

This data frame contains the following columns:

**x** load (in psi)

**n** sample size

**r** number failing

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p13.3)
```

---

p13.4

*Data Set for Problem 13-4*

---

**Description**

The p13.4 data frame has 11 observations on the effectiveness of a price discount coupon on the purchase of a two-litre beverage.

**Usage**

```
data(p13.4)
```

**Format**

This data frame contains the following columns:

**x** discount

**n** sample size

**r** number redeemed

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p13.4)
```

---

p13.5

*Data Set for Problem 13-5*

---

**Description**

The p13.5 data frame has 20 observations on new automobile purchases.

**Usage**

`data(p13.5)`

**Format**

This data frame contains the following columns:

**x1** income

**x2** age of oldest vehicle

**y** new purchase less than 6 months later (1=yes, 0=no)

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

`data(p13.5)`

---

p13.6

*Data Set for Problem 13-6*

---

**Description**

The p13.6 data frame has 15 observations on the number of failures of a particular type of valve in a processing unit.

**Usage**

`data(p13.6)`

**Format**

This data frame contains the following columns:

**valve** type of valve

**numfail** number of failures

**months** months

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p13.6)
```

---

p13.7

*Data Set for Problem 13-7*

---

**Description**

The p13.7 data frame has 44 observations on the coal mines of the Appalachian region of western Virginia.

**Usage**

```
data(p13.7)
```

**Format**

This data frame contains the following columns:

**y** number of fractures in upper seams of coal mines

**x1** inner burden thickness (in feet), shortest distance between seam floor and the lower seam

**x2** percent extraction of the lower previously mined seam

**x3** lower seam height (in feet)

**x4** time that the mine has been in operation (in years)

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**References**

Myers (1990)

**Examples**

```
data(p13.7)
```

---

p14.1

*Data Set for Problem 14-1*

---

**Description**

The p14.1 data frame has 15 rows and 3 columns.

**Usage**

```
data(p14.1)
```

**Format**

This data frame contains the following columns:

**x** a numeric vector

**y** a numeric vector

**time** a numeric vector

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p14.1)
```

---

p14.2

*Data Set for Problem 14-2*

---

**Description**

The p14.2 data frame has 18 rows and 3 columns.

**Usage**

```
data(p14.2)
```

**Format**

This data frame contains the following columns:

**t** a numeric vector

**xt** a numeric vector

**yt** a numeric vector



**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p14.2)
```

---

p15.4

*Data Set for Problem 15-4*

---

**Description**

The p15.4 data frame has 40 rows and 4 columns.

**Usage**

```
data(p15.4)
```

**Format**

This data frame contains the following columns:

**x1** a numeric vector

**x2** a numeric vector

**y** a numeric vector

**set** a factor with levels e and p

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p15.4)
```

---

p2.10

*Data Set for Problem 2-10*

---

**Description**

The p2.10 data frame has 26 observations on weight and systolic blood pressure for randomly selected males in the 25-30 age group.

**Usage**

```
data(p2.10)
```

**Format**

This data frame contains the following columns:

**weight** in pounds

**sysbp** systolic blood pressure

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p2.10)
attach(p2.10)
cor.test(weight, sysbp, method="pearson") # tests rho=0
                                           # and computes 95% CI for rho
                                           # using Fisher's Z-transform
```

---

p2.12

*Data Set for Problem 2-12*

---

**Description**

The p2.12 data frame has 12 observations on the number of pounds of steam used per month at a plant and the average monthly ambient temperature.

**Usage**

```
data(p2.12)
```

**Format**

This data frame contains the following columns:

**temp** ambient temperature (in degrees F)

**usage** usage (in thousands of pounds)

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p2.12)
attach(p2.12)
usage.lm <- lm(usage ~ temp)
summary(usage.lm)
predict(usage.lm, newdata=data.frame(temp=58), interval="prediction")
detach(p2.12)
```

---

p2.13

*Data Set for Problem 2-13*

---

**Description**

The p2.13 data frame has 16 observations on the number of days the ozone levels exceeded 0.2 ppm in the South Coast Air Basin of California for the years 1976 through 1991. It is believed that these levels are related to temperature.

**Usage**

```
data(p2.13)
```

**Format**

This data frame contains the following columns:

**days** number of days ozone levels exceeded 0.2 ppm

**index** a seasonal meteorological index giving the seasonal average 850 millibar temperature.

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**References**

Davidson, A. (1993) Update on Ozone Trends in California's South Coast Air Basin. *Air Waste*, 43, 226-227.

### Examples

```
data(p2.13)
attach(p2.13)
plot(days~index, ylim=c(-20,130))
ozone.lm <- lm(days ~ index)
summary(ozone.lm)
# plots of confidence and prediction intervals:
ozone.conf <- predict(ozone.lm, interval="confidence")
lines(sort(index), ozone.conf[order(index),2], col="red")
lines(sort(index), ozone.conf[order(index),3], col="red")
ozone.pred <- predict(ozone.lm, interval="prediction")
lines(sort(index), ozone.pred[order(index),2], col="blue")
lines(sort(index), ozone.pred[order(index),3], col="blue")
detach(p2.13)
```

---

p2.14

*Data Set for Problem 2-14*

---

### Description

The p2.14 data frame has 8 observations on the molar ratio of sebacic acid and the intrinsic viscosity of copolyesters. One is interested in predicting viscosity from the sebacic acid ratio.

### Usage

```
data(p2.14)
```

### Format

This data frame contains the following columns:

**ratio** molar ratio

**visc** viscosity

### Source

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

### References

Hsuie, Ma, and Tsai (1995) Separation and Characterizations of Thermotropic Copolyesters of p-Hydroxybenzoic Acid, Sebacic Acid and Hydroquinone. Journal of Applied Polymer Science, 56, 471-476.

### Examples

```
data(p2.14)
attach(p2.14)
plot(p2.14, pch=16, ylim=c(0,1))
visc.lm <- lm(visc ~ ratio)
summary(visc.lm)
visc.conf <- predict(visc.lm, interval="confidence")
lines(ratio, visc.conf[,2], col="red")
lines(ratio, visc.conf[,3], col="red")
visc.pred <- predict(visc.lm, interval="prediction")
lines(ratio, visc.pred[,2], col="blue")
lines(ratio, visc.pred[,3], col="blue")
detach(p2.14)
```

---

p2.15

*Data Set for Problem 2-15*

---

### Description

The p2.15 data frame has 8 observations on the impact of temperature on the viscosity of toluene-tetralin blends. This particular data set deals with blends with a 0.4 molar fraction of toluene.

### Usage

```
data(p2.15)
```

### Format

This data frame contains the following columns:

**temp** temperature (in degrees Celsius)

**visc** viscosity (mPa s)

### Source

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

### References

Byers and Williams (1987) Viscosities of Binary and Ternary Mixtures of Polynomatic Hydrocarbons. Journal of Chemical and Engineering Data, 32, 349-354.

**Examples**

```
data(p2.15)
attach(p2.15)
plot(visc ~ temp, pch=16)
visc.lm <- lm(visc ~ temp)
plot(visc.lm, which=1)
detach(p2.15)
```

---

p2.16

*Data Set for Problem 2-16*

---

**Description**

The p2.16 data frame has 33 observations on the pressure in a tank the volume of liquid.

**Usage**

```
data(p2.16)
```

**Format**

This data frame contains the following columns:

**volume** volume of liquid

**pressure** pressure in the tank

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**References**

Carroll and Spiegelman (1986) The Effects of Ignoring Small Measurement Errors in Precision Instrument Calibration. Journal of Quality Technology, 18, 170-173.

**Examples**

```
data(p2.16)
attach(p2.16)
plot(pressure ~ volume, pch=16)
pressure.lm <- lm(pressure ~ volume)
plot(pressure.lm, which=1)
summary(pressure.lm)
detach(p2.16)
```

---

p2.7

*Data Set for Problem 2-7*

---

### Description

The p2.7 data frame has 20 observations on the purity of oxygen produced by a fractionation process. It is thought that oxygen purity is related to the percentage of hydrocarbons in the main condenser of the processing unit.

### Usage

```
data(p2.7)
```

### Format

This data frame contains the following columns:

**purity** oxygen purity (percentage)

**hydro** hydrocarbon (percentage)

### Source

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

### Examples

```
data(p2.7)
attach(p2.7)
purity.lm <- lm(purity ~ hydro)
summary(purity.lm)
# confidence interval for mean purity at 1% hydrocarbon:
predict(purity.lm,newdata=data.frame(hydro = 1.00),interval="confidence")
detach(p2.7)
```

---

p2.9

*Data Set for Problem 2-9*

---

### Description

The p2.9 data frame has 25 rows and 2 columns. See help on softdrink for details.

### Usage

```
data(p2.9)
```

**Format**

This data frame contains the following columns:

**y** a numeric vector

**x** a numeric vector

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p2.9)
```

---

p4.18

*Data Set for Problem 4-18*

---

**Description**

The p4.18 data frame has 13 observations on an experiment to produce a synthetic analogue to jojoba oil.

**Usage**

```
data(p4.18)
```

**Format**

This data frame contains the following columns:

**x1** reaction temperature

**x2** initial amount of catalyst

**x3** pressure

**y** yield

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**References**

Coteron, Sanchez, Matinez, and Aracil (1993) Optimization of the Synthesis of an Analogue of Jojoba Oil Using a Fully Central Composite Design. Canadian Journal of Chemical Engineering.



**Examples**

```
data(p4.18)
y.lm <- lm(y ~ x1 + x2 + x3, data=p4.18)
summary(y.lm)
y.lm <- lm(y ~ x1, data=p4.18)
```

---

p4.19

*Data Set for Problem 4-19*

---

**Description**

The p4.19 data frame has 14 observations on a designed experiment studying the relationship between abrasion index for a tire tread compound and three factors.

**Usage**

```
data(p4.19)
```

**Format**

This data frame contains the following columns:

- x1** hydrated silica level
- x2** silane coupling agent level
- x3** sulfur level
- y** abrasion index for a tire tread compound

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**References**

Derringer and Suich (1980) Simultaneous Optimization of Several Response Variables. Journal of Quality Technology.

**Examples**

```
data(p4.19)
attach(p4.19)
y.lm <- lm(y ~ x1 + x2 + x3)
summary(y.lm)
plot(y.lm, which=1)
y.lm <- lm(y ~ x1)
detach(p4.19)
```

---

p4.20

*Data Set for Problem 4-20*

---

### Description

The p4.20 data frame has 26 observations on a designed experiment to determine the influence of five factors on the whiteness of rayon.

### Usage

```
data(p4.20)
```

### Format

This data frame contains the following columns:

**acidtemp** acid bath temperature

**acidconc** cascade acid concentration

**watertemp** water temperature

**sulfconc** sulfide concentration

**amtbl** amount of chlorine bleach

**y** a measure of the whiteness of rayon

### Source

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

### References

Myers and Montgomery (1995) Response Surface Methodology, pp. 267-268.

### Examples

```
data(p4.20)
y.lm <- lm(y ~ acidtemp, data=p4.20)
summary(y.lm)
```

---

p5.1

*Data Set for Problem 5-1*

---

### Description

The p5.1 data frame has 8 observations on the impact of temperature on the viscosity of toluene-tetralin blends.

### Usage

```
data(p5.1)
```

### Format

This data frame contains the following columns:

**temp** temperature

**visc** viscosity

### Source

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

### References

Byers and Williams (1987) Viscosities of Binary and Ternary Mixtures of Polyaromatic Hydrocarbons. Journal of Chemical and Engineering Data, 32, 349-354.

### Examples

```
data(p5.1)
plot(p5.1)
```

---

p5.10

*Data Set for Problem 5-10*

---

### Description

The p5.10 data frame has 27 observations on the effect of three factors on a printing machine's ability to apply coloring inks on package labels.

### Usage

```
data(p5.10)
```

**Format**

This data frame contains the following columns:

**x1** speed  
**x2** pressure  
**x3** distance  
**yi1** response 1  
**yi2** response 2  
**yi3** response 3  
**ybar.i** average response  
**si** standard deviation of the 3 responses

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p5.10)
attach(p5.10)
y.lm <- lm(ybar.i ~ x1 + x2 + x3)
plot(y.lm, which=1)
detach(p5.10)
```

---

p5.11

*Data Set for Problem 5-11*

---

**Description**

The p5.11 data frame has 8 observations on an experiment with a catapult.

**Usage**

```
data(p5.11)
```

**Format**

This data frame contains the following columns:

**x1** hook  
**x2** arm length  
**x3** start angle  
**x4** stop angle  
**yi1** response 1  
**yi2** response 2  
**yi3** response 3

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p5.11)
attach(p5.11)
ybar.i <- apply(p5.11[,5:7], 1, mean)
sd.i <- apply(p5.11[,5:7], 1, sd)
y.lm <- lm(ybar.i ~ x1 + x2 + x3 + x4)
plot(y.lm, which=1)
detach(p5.11)
```

---

p5.2

*Data Set for Problem 5-2*

---

**Description**

The p5.2 data frame has 11 observations on the vapor pressure of water for various temperatures.

**Usage**

```
data(p5.2)
```

**Format**

This data frame contains the following columns:

**temp** temperature (K)

**vapor** vapor pressure (mm Hg)

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p5.2)
plot(p5.2)
```

---

p5.3

*Data Set for Problem 5-3*

---

### Description

The p5.3 data frame has 12 observations on the number of bacteria surviving in a canned food product and the number of minutes of exposure to 300 degree Fahrenheit heat.

### Usage

```
data(p5.3)
```

### Format

This data frame contains the following columns:

**bact** number of surviving bacteria

**min** number of minutes of exposure

### Source

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

### Examples

```
data(p5.3)
plot(bact~min, data=p5.3)
```

---

p5.4

*Data Set for Problem 5-4*

---

### Description

The p5.4 data frame has 8 observations on 2 variables.

### Usage

```
data(p5.4)
```

### Format

This data frame contains the following columns:

**x** a numeric vector

**y** a numeric vector

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p5.4)
plot(y ~ x, data=p5.4)
```

---

p5.5

*Data Set for Problem 5-5*

---

**Description**

The p5.5 data frame has 14 observations on the average number of defects per 10000 bottles due to stones in the bottle wall and the number of weeks since the last furnace overhaul.

**Usage**

```
data(p5.5)
```

**Format**

This data frame contains the following columns:

**defects** a numeric vector

**weeks** a numeric vector

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p5.5)
defects.lm <- lm(defects~weeks, data=p5.5)
plot(defects.lm, which=1)
```

---

p7.1

*Data Set for Problem 7-1*

---

**Description**

The p7.1 data frame has 10 observations on a predictor variable.

**Usage**

```
data(p7.1)
```

**Format**

This data frame contains the following columns:

**x** a numeric vector

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p7.1)
attach(p7.1)
x2 <- x^2
detach(p7.1)
```

---

p7.11

*Data Set for Problem 7-11*

---

**Description**

The p7.11 data frame has 11 observations on production cost versus production lot size.

**Usage**

```
data(p7.11)
```

**Format**

This data frame contains the following columns:

**x** production lot size

**y** average production cost per unit



**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p7.11)
plot(y ~ x, data=p7.11)
```

---

p7.15

*Data Set for Problem 7-15*

---

**Description**

The p7.15 data frame has 6 observations on vapor pressure of water at various temperatures.

**Usage**

```
data(p7.15)
```

**Format**

This data frame contains the following columns:

**y** vapor pressure (mm Hg)

**x** temperature (degrees Celsius)

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p7.15)
y.lm <- lm(y ~ x, data=p7.15)
plot(y ~ x, data=p7.15)
abline(coef(y.lm))
plot(y.lm, which=1)
```

---

p7.16

*Data Set for Problem 7-16*

---

**Description**

The p7.16 data frame has 26 observations on the observed mole fraction solubility of a solute at a constant temperature.

**Usage**

```
data(p7.16)
```

**Format**

This data frame contains the following columns:

**y** negative logarithm of the mole fraction solubility

**x1** dispersion partial solubility

**x2** dipolar partial solubility

**x3** hydrogen bonding Hansen partial solubility

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**References**

(1991) Journal of Pharmaceutical Sciences 80, 971-977.

**Examples**

```
data(p7.16)  
pairs(p7.16)
```

---

p7.19

*Data Set for Problem 7-19*

---

**Description**

The p7.19 data frame has 10 observations on the concentration of green liquor and paper machine speed from a kraft paper machine.

**Usage**

```
data(p7.19)
```

**Format**

This data frame contains the following columns:

**y** green liquor (g/l)

**x** paper machine speed (ft/min)

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**References**

(1986) Tappi Journal.

**Examples**

```
data(p7.19)
y.lm <- lm(y ~ x + I(x^2), data=p7.19)
summary(y.lm)
```

---

p7.2

*Data Set for Problem 7-2*

---

**Description**

The p7.2 data frame has 10 observations on solid-fuel rocket propellant weight loss.

**Usage**

```
data(p7.2)
```

**Format**

This data frame contains the following columns:

**x** months since production

**y** weight loss (kg)

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p7.2)
y.lm <- lm(y ~ x + I(x^2), data=p7.2)
summary(y.lm)
plot(y ~ x, data=p7.2)
```

---

p7.4

*Data Set for Problem 7-4*

---

**Description**

The p7.4 data frame has 12 observations on two variables.

**Usage**

```
data(p7.4)
```

**Format**

This data frame contains the following columns:

**x** a numeric vector

**y** a numeric vector

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p7.4)
y.lm <- lm(y ~ x + I(x^2), data = p7.4)
summary(y.lm)
```

---

p7.6

*Data Set for Problem 7-6*

---

**Description**

The p7.6 data frame has 12 observations on softdrink carbonation.

**Usage**

```
data(p7.6)
```

**Format**

This data frame contains the following columns:

**y** carbonation

**x1** temperature

**x2** pressure

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p7.6)
y.lm <- lm(y ~ x1 + I(x1^2) + x2 + I(x2^2) + I(x1*x2), data=p7.6)
summary(y.lm)
```

---

p8.11

*Data Set for Problem 8-11*

---

**Description**

The p8.11 data frame has 25 observations on the tensile strength of synthetic fibre used for men's shirts.

**Usage**

```
data(p8.11)
```

**Format**

This data frame contains the following columns:

**y** tensile strength

**percent** percentage of cotton

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**References**

Montgomery (2001)

**Examples**

```
data(p8.11)
y.lm <- lm(y ~ percent, data=p8.11)
model.matrix(y.lm)
```

---

p8.3

*Data Set for Problem 8-3*

---

**Description**

The p8.3 data frame has 25 observations on delivery times taken by a vending machine route driver.

**Usage**

```
data(p8.3)
```

**Format**

This data frame contains the following columns:

**y** delivery time (in minutes)

**x1** number of cases of product stocked

**x2** distance walked by route driver

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(p8.3)
pairs(p8.3)
```

---

p9.10

*Data Set for Problem 9-10*

---

**Description**

The p9.10 data frame has 31 observations on the rut depth of asphalt pavements prepared under different conditions.

**Usage**

```
data(p9.10)
```

**Format**

This data frame contains the following columns:

**y** change in rut depth/million wheel passes (log scale)

**x1** viscosity (log scale)

**x2** percentage of asphalt in surface course

**x3** percentage of asphalt in base course

**x4** indicator

**x5** percentage of fines in surface course

**x6** percentage of voids in surface course

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**References**

Gorman and Toman (1966)

**Examples**

```
data(p9.10)
pairs(p9.10)
```

---

pathoeg

*Pathological Example*

---

**Description**

Artificial regression data which causes stepwise regression with AIC to produce a highly non-parsimonious model. The true model used to simulate the data has only one real predictor (x8).

**Usage**

```
pathoeg
```

**Format**

This data frame contains the following columns:

**x1** a numeric vector

**x2** a numeric vector

**x3** a numeric vector

**x4** a numeric vector

**x5** a numeric vector  
**x6** a numeric vector  
**x7** a numeric vector  
**x8** a numeric vector  
**x9** a numeric vector  
**y** a numeric vector

---

PRESS

*PRESS statistic*

---

### **Description**

Computation of Allen's PRESS statistic for an lm object.

### **Usage**

PRESS(x)

### **Arguments**

x                    An lm object

### **Value**

Allen's PRESS statistic.

### **Author(s)**

W.J. Braun

### **See Also**

lm

### **Examples**

```
data(p4.18)
attach(p4.18)
y.lm <- lm(y ~ x1 + I(x1^2))
PRESS(y.lm)
detach(p4.18)
```



---

qqANOVA	<i>QQ Plot for Analysis of Variance</i>
---------	---

---

**Description**

This function is used to display the weight of the evidence against null main effects in data coming from a 1 factor design, using a QQ plot. In practice this method is often called via the function GANOVA.

**Usage**

```
qqANOVA(x, y, plot.it = TRUE, xlab = deparse(substitute(x)),  
        ylab = deparse(substitute(y)), ...)
```

**Arguments**

x	numeric vector of errors
y	numeric vector of scaled responses
plot.it	logical vector indicating whether to plot or not
xlab	character, x-axis label
ylab	character, y-axis label
...	any other arguments for the plot function

**Value**

A QQ plot is drawn.

**Author(s)**

W. John Braun

---

quadline	<i>Quadratic Overlay</i>
----------	--------------------------

---

**Description**

Overlays a quadratic curve to a fitted quadratic model.

**Usage**

```
quadline(lm.obj, ...)
```

**Arguments**

lm.obj	A lm object (a quadratic fit)
...	Other arguments to the lines function; e.g. col

**Value**

The function superimposes a quadratic curve onto an existing scatterplot.

**Author(s)**

W.J. Braun

**See Also**

lm

**Examples**

```
data(p4.18)
attach(p4.18)
y.lm <- lm(y ~ x1 + I(x1^2))
plot(x1, y)
quadline(y.lm)
detach(p4.18)
```

---

Qyplot

*Analysis of Variance Plot for Regression*

---

**Description**

This function analyzes regression data graphically. It allows visualization of the usual F-test for significance of regression.

**Usage**

```
Qyplot(X, y, plotIt=TRUE, sortTrt=FALSE, type="hist", includeIntercept=TRUE, labels=FALSE)
```

**Arguments**

X	The design matrix.
y	A numeric vector containing the response.
plotIt	Logical: if TRUE, a graph is drawn.
sortTrt	Logical: if TRUE, an attempt is made at sorting the predictor effects in descending order.
type	"QQ" or "hist"

includeIntercept	Logical: if TRUE, the intercept effect is plotted; otherwise, it is omitted from the plot.
labels	logical: if TRUE, names of predictor variables are used as labels; otherwise, the design matrix column numbers are used as labels

**Value**

A QQ-plot or a histogram and rugplot, or a list if plotIt=FALSE

**Author(s)**

W. John Braun

**Source**

Braun, W.J. 2013. Regression Analysis and the QR Decomposition. Preprint.

**Examples**

```
# Example 1
X <- p4.18[,-4]
y <- p4.18[,4]
Qyplot(X, y, type="hist", includeIntercept=FALSE)
title("Evidence of Regression in the Jojoba Oil Data")
# Example 2
set.seed(4571)
Z <- matrix(rnorm(400), ncol=10)
A <- matrix(rnorm(81), ncol=9)
simdata <- data.frame(Z[,1], crossprod(t(Z[, -1]), A))
names(simdata) <- c("y", paste("x", 1:9, sep=""))
Qyplot(simdata[, -1], simdata[, 1], type="hist", includeIntercept=FALSE)
title("Evidence of Regression in Simulated Data Set")
# Example 3
Qyplot(table.b1[, -1], table.b1[, 1], type="hist", includeIntercept=FALSE)
title("Evidence of Regression in NFL Data Set")
# An example where stepwise AIC selects the complement
# of the set of variables that are actually in the true model:
X <- pathoeg[, -10]
y <- pathoeg[, 10]
par(mfrow=c(2,2))
Qyplot(X, y)
Qyplot(X, y, sortTrt=TRUE)
Qyplot(X, y, type="QQ")
Qyplot(X, y, sortTrt=TRUE, type="QQ")
X <- table.b1[, -1] # NFL data
y <- table.b1[, 1]
Qyplot(X, y)
```

---

softdrink

*Softdrink Data*

---

### Description

The softdrink data frame has 25 rows and 3 columns.

### Usage

```
data(softdrink)
```

### Format

This data frame contains the following columns:

**y** a numeric vector

**x1** a numeric vector

**x2** a numeric vector

### Source

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

### Examples

```
data(softdrink)
```

---

solar

*Solar Data*

---

### Description

The solar data frame has 29 rows and 6 columns.

### Usage

```
data(solar)
```

**Format**

This data frame contains the following columns:

**total.heat.flux** a numeric vector

**insolation** a numeric vector

**focal.pt.east** a numeric vector

**focal.pt.south** a numeric vector

**focal.pt.north** a numeric vector

**time.of.day** a numeric vector

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(solar)
```

---

stain

*Stain Removal Data*

---

**Description**

Data on an experiment to remove ketchup stains from white cotton fabric by soaking the stained fabric in one of five substrates for one hour. Remaining stains were scored visually and subjectively according to a 6-point scale (0 = completely clean, 5 = no change) The `stain` data frame has 15 rows and 2 columns.

**Usage**

```
data(stain)
```

**Format**

This data frame contains the following columns:

**treatment** a factor

**response** a numeric vector

**Examples**

```
data(stain)
```

---

table.b1	<i>Table B1</i>
----------	-----------------

---

**Description**

The table.b1 data frame has 28 observations on National Football League 1976 Team Performance.

**Usage**

```
data(table.b1)
```

**Format**

This data frame contains the following columns:

**y** Games won in a 14 game season

**x1** Rushing yards

**x2** Passing yards

**x3** Punting average (yards/punt)

**x4** Field Goal Percentage (FGs made/FGs attempted)

**x5** Turnover differential (turnovers acquired - turnovers lost)

**x6** Penalty yards

**x7** Percent rushing (rushing plays/total plays)

**x8** Opponents' rushing yards

**x9** Opponents' passing yards

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(table.b1)
attach(table.b1)
y.lm <- lm(y ~ x2 + x7 + x8)
summary(y.lm)
# over-all F-test:
y.null <- lm(y ~ 1)
anova(y.null, y.lm)
# partial F-test for x7:
y7.lm <- lm(y ~ x2 + x8)
anova(y7.lm, y.lm)
detach(table.b1)
```

---

table.b10	<i>Table B10</i>
-----------	------------------

---

**Description**

The table.b10 data frame has 40 observations on kinematic viscosity of a certain solvent system.

**Usage**

```
data(table.b10)
```

**Format**

This data frame contains the following columns:

**x1** Ratio of 2-methoxyethanol to 1,2-dimethoxyethane

**x2** Temperature (in degrees Celsius)

**y** Kinematic viscosity (.000001 m<sup>2</sup>/s)

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**References**

Viscosimetric Studies on 2-Methoxyethanol + 1, 2-Dimethoxyethane Binary Mixtures from -10 to 80C. Canadian Journal of Chemical Engineering, 75, 494-501.

**Examples**

```
data(table.b10)
attach(table.b10)
y.lm <- lm(y ~ x1 + x2)
summary(y.lm)
detach(table.b10)
```

---

`table.b11`*Table B11*

---

**Description**

The `table.b11` data frame has 38 observations on the quality of Pinot Noir wine.

**Usage**

```
data(table.b11)
```

**Format**

This data frame contains the following columns:

**Clarity** a numeric vector

**Aroma** a numeric vector

**Body** a numeric vector

**Flavor** a numeric vector

**Oakiness** a numeric vector

**Quality** a numeric vector

**Region** a numeric vector

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(table.b11)
attach(table.b11)
Quality.lm <- lm(Quality ~ Clarity + Aroma + Body + Flavor + Oakiness +
  factor(Region))
summary(Quality.lm)
detach(table.b11)
```



---

table.b12	<i>Table B12</i>
-----------	------------------

---

**Description**

The table.b12 data frame has 32 rows and 6 columns.

**Usage**

```
data(table.b12)
```

**Format**

This data frame contains the following columns:

**temp** a numeric vector

**soaktime** a numeric vector

**soakpct** a numeric vector

**difftime** a numeric vector

**diffpct** a numeric vector

**pitch** a numeric vector

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(table.b12)
```

---

table.b13	<i>Table B13</i>
-----------	------------------

---

**Description**

The table.b13 data frame has 40 rows and 7 columns.

**Usage**

```
data(table.b13)
```

**Format**

This data frame contains the following columns:

**y** a numeric vector  
**x1** a numeric vector  
**x2** a numeric vector  
**x3** a numeric vector  
**x4** a numeric vector  
**x5** a numeric vector  
**x6** a numeric vector

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(table.b13)
```

---

table.b14

*Table B14*

---

**Description**

The table.b14 data frame has 25 observations on the transient points of an electronic inverter.

**Usage**

```
data(table.b14)
```

**Format**

This data frame contains the following columns:

**x1** width of the NMOS Device  
**x2** length of the NMOS Device  
**x3** width of the PMOS Device  
**x4** length of the PMOS Device  
**x5** a numeric vector  
**y** transient point of PMOS-NMOS Inverters

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(table.b14)
y.lm <- lm(y ~ x1 + x2 + x3 + x4, data=table.b14)
plot(y.lm, which=1)
```

---

table.b2	<i>Table B2</i>
----------	-----------------

---

**Description**

The table.b2 data frame has 29 rows and 6 columns.

**Usage**

```
data(table.b2)
```

**Format**

This data frame contains the following columns:

**y** a numeric vector

**x1** a numeric vector

**x2** a numeric vector

**x3** a numeric vector

**x4** a numeric vector

**x5** a numeric vector

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**Examples**

```
data(table.b2)
```

---

table.b3

*Table B3*

---

### Description

The table.b3 data frame has observations on gasoline mileage performance for 32 different automobiles.

### Usage

```
data(table.b3)
```

### Format

This data frame contains the following columns:

**y** Miles/gallon

**x1** Displacement (cubic in)

**x2** Horsepower (ft-lb)

**x3** Torque (ft-lb)

**x4** Compression ratio

**x5** Rear axle ratio

**x6** Carburetor (barrels)

**x7** No. of transmission speeds

**x8** Overall length (in)

**x9** Width (in)

**x10** Weight (lb)

**x11** Type of transmission (1=automatic, 0=manual)

### Source

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

### References

Motor Trend, 1975

**Examples**

```
data(table.b3)
attach(table.b3)
y.lm <- lm(y ~ x1 + x6)
summary(y.lm)
# testing for the significance of the regression:
y.null <- lm(y ~ 1)
anova(y.null, y.lm)
# 95% CI for mean gas mileage:
predict(y.lm, newdata=data.frame(x1=275, x6=2), interval="confidence")
# 95% PI for gas mileage:
predict(y.lm, newdata=data.frame(x1=275, x6=2), interval="prediction")
detach(table.b3)
```

---

table.b4
----------

---

*Table B4***Description**

The table.b4 data frame has 24 observations on property valuation.

**Usage**

```
data(table.b4)
```

**Format**

This data frame contains the following columns:

- y** sale price of the house (in thousands of dollars)
- x1** taxes (in thousands of dollars)
- x2** number of baths
- x3** lot size (in thousands of square feet)
- x4** living space (in thousands of square feet)
- x5** number of garage stalls
- x6** number of rooms
- x7** number of bedrooms
- x8** age of the home (in years)
- x9** number of fireplaces

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

## References

Narula, S.C. and Wellington (1980) Prediction, Linear Regression and Minimum Sum of Relative Errors. *Technometrics*, 19, 1977.

## Examples

```
data(table.b4)
attach(table.b4)
y.lm <- lm(y ~ x1 + x2 + x3 + x4 + x5 + x6 + x7 + x8 + x9)
summary(y.lm)
detach(table.b4)
```

---

table.b5

*Data Set for Table B5*

---

## Description

The table.b5 data frame has 27 observations on liquefaction.

## Usage

```
data(table.b5)
```

## Format

This data frame contains the following columns:

**y** CO2  
**x1** Space time (in min)  
**x2** Temperature (in degrees Celsius)  
**x3** Percent solvation  
**x4** Oil yield (g/100g MAF)  
**x5** Coal total  
**x6** Solvent total  
**x7** Hydrogen consumption

## Source

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) *Introduction to Linear Regression Analysis*. 3rd Edition, John Wiley and Sons.

## References

(1978) Belle Ayr Liquefaction Runs with Solvent. *Industrial Chemical Process Design Development*, 17, 3.

**Examples**

```
data(table.b5)
attach(table.b5)
y.lm <- lm(y ~ x6 + x7)
summary(y.lm)
detach(table.b5)
```

---

table.b6	<i>Data Set for Table B6</i>
----------	------------------------------

---

**Description**

The table.b6 data frame has 28 observations on a tube-flow reactor.

**Usage**

```
data(table.b6)
```

**Format**

This data frame contains the following columns:

**y** NbOCl3 concentration (g-mol/l)  
**x1** COCl2 concentration (g-mol/l)  
**x2** Space time (s)  
**x3** Molar density (g-mol/l)  
**x4** Mole fraction CO2

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**References**

(1972) Kinetics of Chlorination of Niobium oxychloride by Phosgene in a Tube-Flow Reactor. Industrial and Engineering Chemistry, Process Design Development, 11(2).

**Examples**

```
data(table.b6)
# Partial Solution to Problem 3.9
attach(table.b6)
y.lm <- lm(y ~ x1 + x4)
summary(y.lm)
detach(table.b6)
```

---

`table.b7`*Data Set for Table B7*

---

**Description**

The `table.b7` data frame has 16 observations on oil extraction from peanuts.

**Usage**

```
data(table.b7)
```

**Format**

This data frame contains the following columns:

- x1** CO2 pressure (bar)
- x2** CO2 temperature (in degrees Celsius)
- x3** peanut moisture (percent by weight)
- x4** CO2 flow rate (L/min)
- x5** peanut particle size (mm)
- y** total oil yield

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**References**

Kilgo, M.B. An Application of Fractional Experimental Designs. Quality Engineering, 1, 19-23.

**Examples**

```
data(table.b7)
attach(table.b7)
# partial solution to Problem 3.11:
peanuts.lm <- lm(y ~ x1 + x2 + x3 + x4 + x5)
summary(peanuts.lm)
detach(table.b7)
```



---

table.b8	<i>Table B8</i>
----------	-----------------

---

**Description**

The table.b8 data frame has 36 observations on Clathrate formation.

**Usage**

```
data(table.b8)
```

**Format**

This data frame contains the following columns:

**x1** Amount of surfactant (mass percentage)

**x2** Time (min)

**y** Clathrate formation (mass percentage)

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**References**

Tanii, T., Minemoto, M., Nakazawa, K., and Ando, Y. Study on a Cool Storage System Using HCFC-14 lb Clathrate. Canadian Journal of Chemical Engineering, 75, 353-360.

**Examples**

```
data(table.b8)
attach(table.b8)
clathrate.lm <- lm(y ~ x1 + x2)
summary(clathrate.lm)
detach(table.b8)
```

---

`table.b9`*Data Set for Table B9*

---

**Description**

The `table.b9` data frame has 62 observations on an experimental pressure drop.

**Usage**

```
data(table.b9)
```

**Format**

This data frame contains the following columns:

- x1** Superficial fluid velocity of the gas (cm/s)
- x2** Kinematic viscosity
- x3** Mesh opening (cm)
- x4** Dimensionless number relating superficial fluid velocity of the gas to the superficial fluid velocity of the liquid
- y** Dimensionless factor for the pressure drop through a bubble cap

**Source**

Montgomery, D.C., Peck, E.A., and Vining, C.G. (2001) Introduction to Linear Regression Analysis. 3rd Edition, John Wiley and Sons.

**References**

Liu, C.H., Kan, M., and Chen, B.H. A Correlation of Two-Phase Pressure Drops in Screen-Plate Bubble Column. Canadian Journal of Chemical Engineering, 71, 460-463.

**Examples**

```
data(table.b9)
attach(table.b9)
# Partial Solution to Problem 3.13:
y.lm <- lm(y ~ x1 + x2 + x3 + x4)
summary(y.lm)
detach(table.b9)
```

---

tarimage	<i>target image</i>
----------	---------------------

---

**Description**

The tarimage is a list. Most of the values are 0, but there are small regions of 1's.

**Usage**

```
data(tarimage)
```

**Format**

This list contains the following elements:

**x** a numeric vector having 101 elements.

**y** a numeric vector having 101 elements.

**xy** a numeric matrix having 101 rows and columns

**Examples**

```
with(tarimage, image(x, y, xy))
```

---

tplot	<i>Graphical t Test for Regression</i>
-------	--

---

**Description**

This function analyzes regression data graphically. It allows visualization of the usual t-tests for individual regression coefficients.

**Usage**

```
tplot(X, y, plotIt=TRUE, type="hist", includeIntercept=TRUE)
```

**Arguments**

**X** The design matrix.

**y** A numeric vector containing the response.

**plotIt** Logical: if TRUE, a graph is drawn.

**type** "QQ" or "hist"

**includeIntercept** Logical: if TRUE, the intercept effect is plotted; otherwise, it is omitted from the plot.

**Value**

A QQ-plot or a histogram and rugplot, or a list if plotIt=FALSE

**Author(s)**

W. John Braun

**Examples**

```
# Jojoba oil data set
X <- p4.18[,-4]
y <- p4.18[,4]
tplot(X, y, type="hist", includeIntercept=FALSE)
title("Tests for Individual Coefficients in the Jojoba Oil Regression")
# Simulated data set where none of the predictors are in the true model:
set.seed(4571)
Z <- matrix(rnorm(400), ncol=10)
A <- matrix(rnorm(81), ncol=9)
simdata <- data.frame(Z[,1], crossprod(t(Z[,-1]),A))
names(simdata) <- c("y", paste("x", 1:9, sep=""))
X <- simdata[,-1]
y <- simdata[,1]
tplot(X, y, type="hist", includeIntercept=FALSE)
title("Tests for Individual Coefficients for the Simulated Data Set")
# NFL Data set:
X <- table.b1[,-1]
y <- table.b1[,1]
tplot(X, y, type="hist", includeIntercept=FALSE)
title("Tests for Individual Coefficients for the NFL Data Set")
# Simulated Data set where x8 is the only predictor in the true model:
X <- pathoeg[,-10]
y <- pathoeg[,10]
par(mfrow=c(2,2))
tplot(X, y)
tplot(X, y, type="QQ")
```

---

Uplot

*Plot of Multipliers in Regression ANOVA Plot*

---

**Description**

This function graphically displays the coefficient multipliers used in the Regression Plot for the given predictor.

**Usage**

```
Uplot(X.qr, Xcolumn = 1, ...)
```

**Arguments**

<code>X.qr</code>	The design matrix or the QR decomposition of the design matrix.
<code>Xcolumn</code>	The column(s) of the design matrix under study; this can be either integer valued or a character string.
<code>...</code>	Additional arguments to <code>barchart</code> .

**Value**

A bar plot is displayed.

**Author(s)**

W. John Braun

**Examples**

```
# Jojoba oil data set
X <- p4.18[,-4]
Uplot(X, 1:4)
# NFL data set; see GFplot result first
X <- table.b1[,-1]
Uplot(X, c(2,3,9))
# In this example, x8 is the only predictor in
# the true model:
X <- pathoeg[,-10]
y <- pathoeg[,10]
pathoeg.F <- GFplot(X, y, plotIt=FALSE)
Uplot(X, "x8")
Uplot(X, 9) # same as above
Uplot(pathoeg.F$QR, 9) # same as above
X <- table.b1[,-1]
Uplot(X, c("x2", "x3", "x9"))
```

---

windWin80

*Winnipeg Wind Speed*

---

**Description**

The `windWin80` data frame has 366 observations on midnight and noon windspeed at the Winnipeg International Airport for the year 1980.

**Usage**

```
data(windWin80)
```

**Format**

This data frame contains the following columns:

**h0** a numeric vector containing the wind speeds at midnight.

**h12** a numeric vector containing the wind spees at the following noon.

**Examples**

```
data(windWin80)  
ts.plot(windWin80$h12^2)
```

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