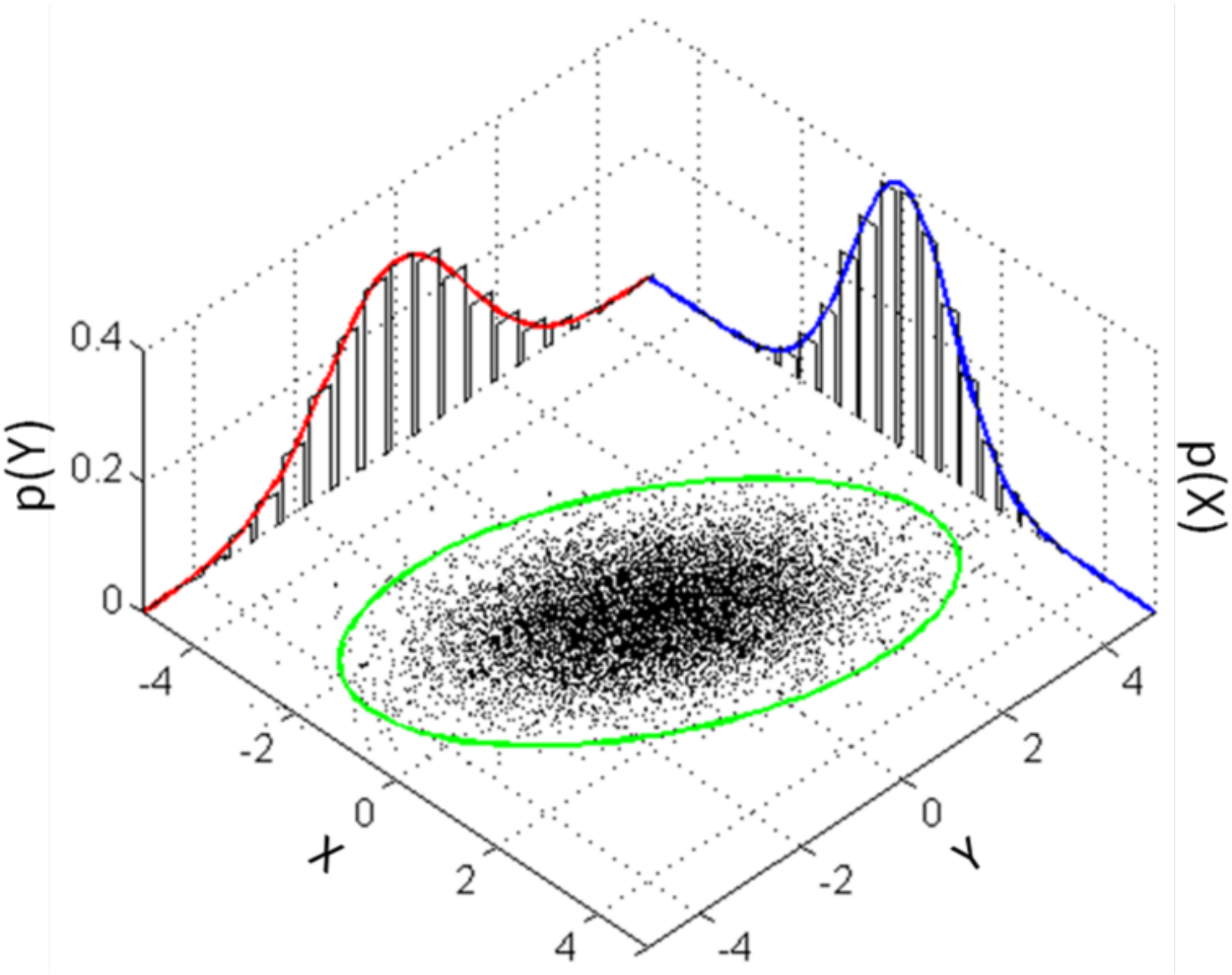
Multivariate Normal

- The multivariate normal distribution (or multivariate Gaussian distribution), is a generalization of the one-dimensional (univariate) normal distribution to higher dimensions.
- The multivariate normal distribution is often used to describe, at least approximately, any set of (possibly) correlated real-valued random variables each of which clusters around a mean value.

Testing for Normality



Testing for Normality

Hypothesis Tests for Univariate Data

Graphical Methods

- Histograms (with Kerney Density Estimation Line)
- Normal Probability Plots

Formal Hypothesis Tests

- Shapiro-Wilk Test (inbuilt with R)
- Anderson-Darling Test (nortest package)
- D'Agostino Test (MSQC package)

Testing for Normality

Hypothesis Tests for Multivariate Data

- Mardia Test (MSQC package)
- Henze and Zirkler (MSQC package)
- Royston Test (MSQC package)

Testing for Normality

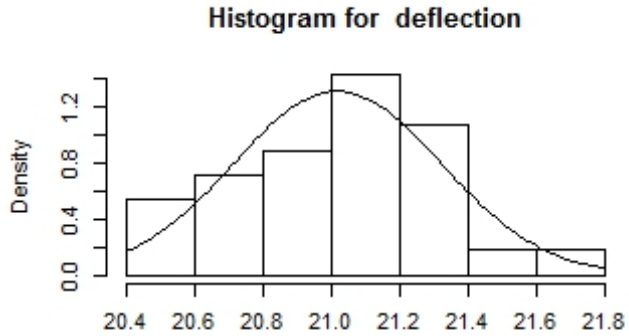
The bimetal data set (MSQC package)

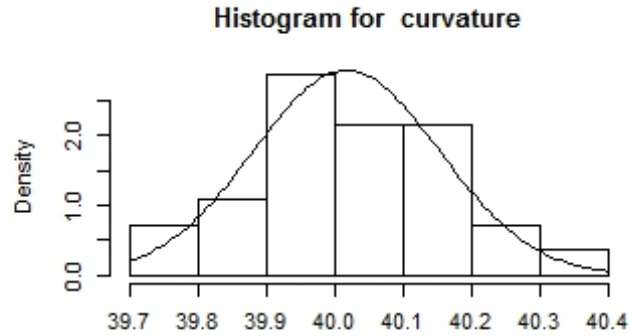
- Bimetal thermostat has innumerable practical uses. These types of thermostats hold a bimetallic strip composed by two strips of different metals that convert the changing of temperature in mechanical displacement due to the difference in thermal expansion.
- Certain type of strip composed of brass and steel is analyzed in a quality laboratory by testing the deflection, curvature, resistivity, and hardness in low and high expansion sides.

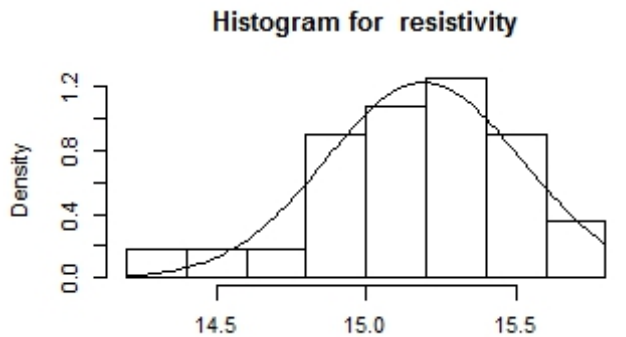
Testing for Normality

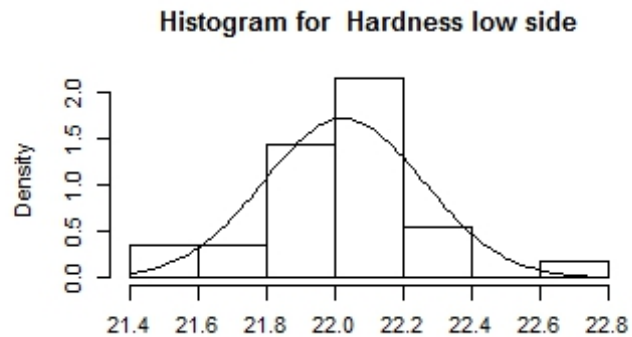
```
> tail(bimetal1)
deflection curvature resistivity Hardness low side Hard
[23,]      20.76     39.98        14.98                22.2
[24,]      21.00     40.11        15.17                22.0
[25,]      20.57     39.73        14.35                22.0
[26,]      20.78     39.83        15.27                21.6
[27,]      20.96     40.03        15.26                21.9
[28,]      21.14     39.93        14.98                21.8
```

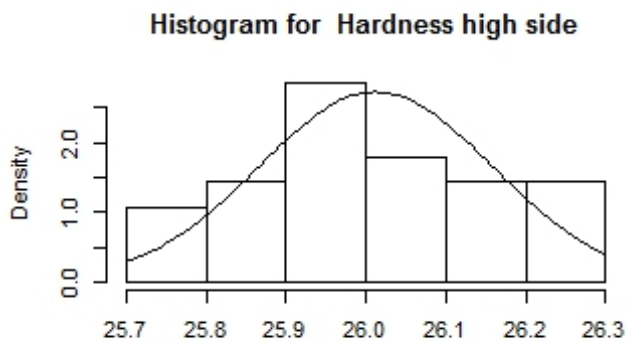
Testing for Normality



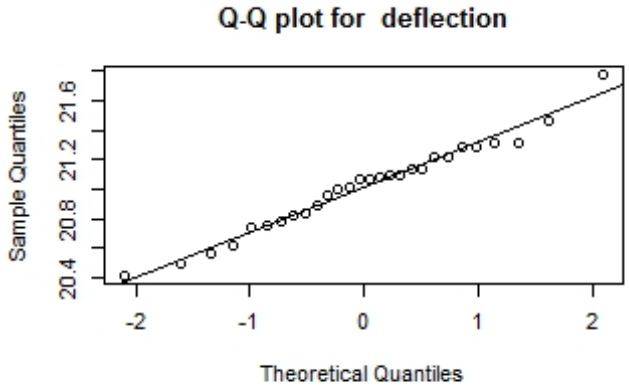


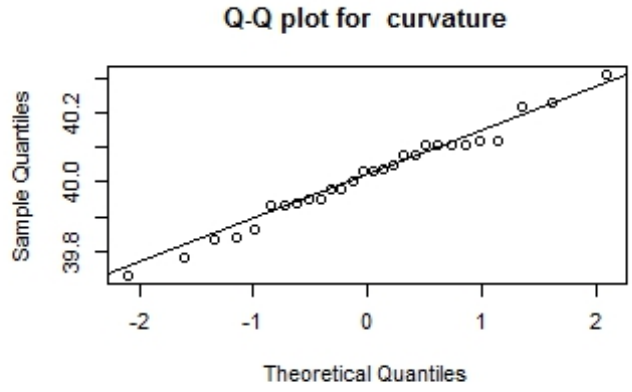


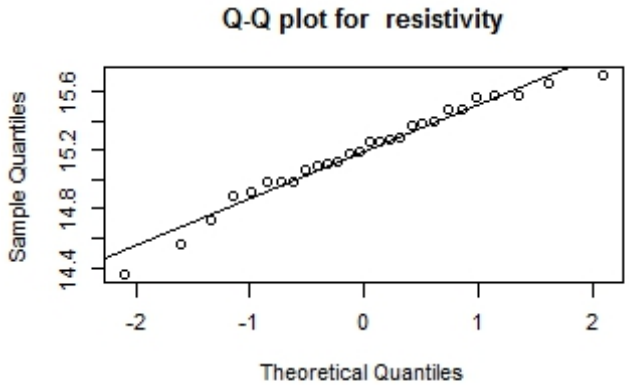


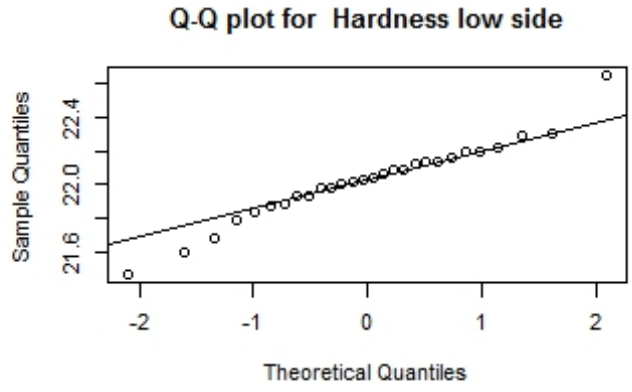


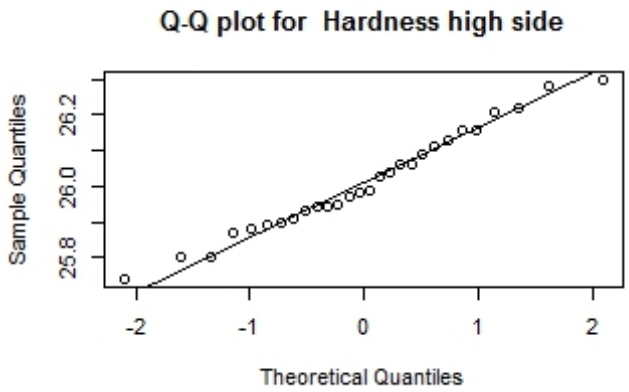
Testing for Normality











Testing for Normality

D'Agostino Test (MSQC Package)

- Using the bimetal1 data set in MSQC package

```
> for (i in 1 : 5){
+  DAGOSTINO(bimetal1[,i])
+  }
```

Testing for Normality

```
D'Agostino Test
Skewness
Skewness coefficient: 0.0831225
Statistics: 0.2117358
p-value: 0.8323131
Kurtosis
The kurtosis coefficient: 3.0422
Statistics: 0.591983
p-value: 0.553862
Omnibus Test
Chi-squared: 0.3952759
Degree of freedom: 2
p-value: 0.8206669
```

Testing for Normality

```
....
D'Agostino Test
Skewness
Skewness coefficient: -0.04173762
Statistics: -0.1063873
p-value: 0.9152751
Kurtosis
The kurtosis coefficient: 4.162062
Statistics: 1.675258
p-value: 0.09388364
Omnibus Test
Chi-squared: 2.817807
Degree of freedom: 2
p-value: 0.2444111
```

Testing for Normality

Some Multivariate (MSQC Pacakge)

```
> MardiaTest(bimetal1)
$skewness
[1] 6.982112

$p.value
[1] 0.585327

$kurtosis
[1] 33.77373

$p.value
[1] 0.3490892
```

Testing for Normality

```
>
> HZ.test(bimetal1)
[1] 0.6068650 0.7709586
>
```

Testing for Normality

```
> Royston.test(bimetal1)
test.statistic          p.value
1.1814742       0.9364221
```

Testing for Normality

Box Cox Transformation

- The Box-Cox transforms non-normally distributed data to a set of data that has approximately normal distribution.