PV data - Parameter estimation and sample generation

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We consider the first column of the data given in PVdata2.csv. Let's generate a matrix where each line represents a day and each column represents one minute of this day:

```
PV1<-PVdata[1:1440,1] #24*60=1440
for (i in 1:30) {
  PV1<-cbind(PV1,PVdata[((i*1440)+1):((i+1)*1440),1])
}
PV1<-t(PV1)
```

1. Normal distribution

2. 1 Parameter estimation - multivariate (dependent) for 1h intervals

We obtain an estimation for the values of expectation and the covariance matrix under the assumption of a normal distribution for the values every hour:

```
PV1h<-matrix(rep(0,744),nrow=31) #hourly values -> take means
for(i in 1:31){
  for (j in 1:24){
    PV1h[i,j]<-mean(PV1[i,((j-1)*60+1):(j*60)])
  }
}

estimates_n_dep<-mlest(PV1h) #under assumption of no independence: hourly means and covariance matrix

estimates_n_dep$muhat #estimate of mean (mu)
```

```
##  [1] -4.130e-09 -4.130e-09 -4.130e-09 -4.130e-09 -4.130e-09 -4.130e-09
##  [7]  2.000e+00  4.244e+02  1.086e+03  1.641e+03  2.026e+03  2.262e+03
## [13]  2.253e+03  2.212e+03  1.874e+03  1.358e+03  7.384e+02  5.380e+01
## [19] -4.130e-09 -4.130e-09 -4.130e-09 -4.130e-09 -4.130e-09 -4.130e-09
```

```
estimates_n_dep$sigmahat #estimate of covariance matrix (sigma)
```

```
##             [,1]      [,2]      [,3]      [,4]      [,5]      [,6]
##  [1,] 0.0001377 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
##  [2,] 0.0000000 0.0001377 0.0000000 0.0000000 0.0000000 0.0000000
##  [3,] 0.0000000 0.0000000 0.0001377 0.0000000 0.0000000 0.0000000
##  [4,] 0.0000000 0.0000000 0.0000000 0.0001377 0.0000000 0.0000000
##  [5,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0001377 0.0000000
##  [6,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0001377
##  [7,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
##  [8,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
##  [9,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
```

```
## [10,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [11,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [12,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [13,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [14,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [15,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [16,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [17,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [18,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [19,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [20,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [21,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [22,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [23,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
## [24,] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
##           [,7]      [,8]      [,9]     [,10]     [,11]     [,12]
##  [1,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [2,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [3,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [4,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [5,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [6,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [7,] 1.665e+00 1.016e+02 2.306e+02 1.970e+02 2.243e+02 1.545e+02
##  [8,] 1.016e+02 2.489e+04 6.212e+04 8.897e+04 1.071e+05 1.055e+05
##  [9,] 2.306e+02 6.212e+04 1.577e+05 2.257e+05 2.721e+05 2.694e+05
## [10,] 1.970e+02 8.897e+04 2.257e+05 3.531e+05 4.296e+05 4.420e+05
## [11,] 2.243e+02 1.071e+05 2.721e+05 4.296e+05 5.281e+05 5.468e+05
## [12,] 1.545e+02 1.055e+05 2.694e+05 4.420e+05 5.468e+05 6.088e+05
## [13,] 2.484e+01 1.067e+05 2.743e+05 4.658e+05 5.786e+05 6.461e+05
## [14,] 8.870e+01 7.870e+04 1.998e+05 3.410e+05 4.244e+05 4.734e+05
## [15,] 1.495e+02 7.840e+04 1.982e+05 3.194e+05 3.968e+05 4.150e+05
## [16,] 1.230e+02 6.866e+04 1.739e+05 2.673e+05 3.268e+05 3.206e+05
## [17,] 7.585e+01 3.769e+04 9.666e+04 1.455e+05 1.762e+05 1.779e+05
## [18,] 7.215e+00 3.623e+03 9.375e+03 1.327e+04 1.610e+04 1.738e+04
## [19,] 3.082e-06 2.109e-03 5.373e-03 8.743e-03 1.079e-02 1.162e-02
## [20,] 3.082e-06 2.109e-03 5.373e-03 8.743e-03 1.079e-02 1.162e-02
## [21,] 3.082e-06 2.109e-03 5.373e-03 8.743e-03 1.079e-02 1.162e-02
## [22,] 3.082e-06 2.109e-03 5.373e-03 8.743e-03 1.079e-02 1.162e-02
## [23,] 3.082e-06 2.109e-03 5.373e-03 8.743e-03 1.079e-02 1.162e-02
## [24,] 3.082e-06 2.109e-03 5.373e-03 8.743e-03 1.079e-02 1.162e-02
##           [,13]     [,14]     [,15]     [,16]     [,17]     [,18]
##  [1,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [2,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [3,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [4,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [5,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [6,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [7,] 2.484e+01 8.870e+01 1.495e+02 1.230e+02 7.585e+01 7.215e+00
##  [8,] 1.067e+05 7.870e+04 7.840e+04 6.866e+04 3.769e+04 3.623e+03
##  [9,] 2.743e+05 1.998e+05 1.982e+05 1.739e+05 9.666e+04 9.375e+03
## [10,] 4.658e+05 3.410e+05 3.194e+05 2.673e+05 1.455e+05 1.327e+04
## [11,] 5.786e+05 4.244e+05 3.968e+05 3.268e+05 1.762e+05 1.610e+04
## [12,] 6.461e+05 4.734e+05 4.150e+05 3.206e+05 1.779e+05 1.738e+04
## [13,] 7.022e+05 5.119e+05 4.461e+05 3.473e+05 1.895e+05 1.825e+04
```

```
## [14,] 5.119e+05 4.757e+05 4.145e+05 3.089e+05 1.692e+05 1.656e+04
## [15,] 4.461e+05 4.145e+05 3.856e+05 3.048e+05 1.636e+05 1.587e+04
## [16,] 3.473e+05 3.089e+05 3.048e+05 2.677e+05 1.435e+05 1.422e+04
## [17,] 1.895e+05 1.692e+05 1.636e+05 1.435e+05 8.194e+04 8.822e+03
## [18,] 1.825e+04 1.656e+04 1.587e+04 1.422e+04 8.822e+03 1.369e+03
## [19,] 1.243e-02 9.736e-03 8.794e-03 6.991e-03 3.812e-03 3.659e-04
## [20,] 1.243e-02 9.736e-03 8.794e-03 6.991e-03 3.812e-03 3.659e-04
## [21,] 1.243e-02 9.736e-03 8.794e-03 6.991e-03 3.812e-03 3.659e-04
## [22,] 1.243e-02 9.736e-03 8.794e-03 6.991e-03 3.812e-03 3.659e-04
## [23,] 1.243e-02 9.736e-03 8.794e-03 6.991e-03 3.812e-03 3.659e-04
## [24,] 1.243e-02 9.736e-03 8.794e-03 6.991e-03 3.812e-03 3.659e-04
##           [,19]     [,20]     [,21]     [,22]     [,23]     [,24]
##  [1,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [2,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [3,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [4,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [5,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [6,] 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
##  [7,] 3.082e-06 3.082e-06 3.082e-06 3.082e-06 3.082e-06 3.082e-06
##  [8,] 2.109e-03 2.109e-03 2.109e-03 2.109e-03 2.109e-03 2.109e-03
##  [9,] 5.373e-03 5.373e-03 5.373e-03 5.373e-03 5.373e-03 5.373e-03
## [10,] 8.743e-03 8.743e-03 8.743e-03 8.743e-03 8.743e-03 8.743e-03
## [11,] 1.079e-02 1.079e-02 1.079e-02 1.079e-02 1.079e-02 1.079e-02
## [12,] 1.162e-02 1.162e-02 1.162e-02 1.162e-02 1.162e-02 1.162e-02
## [13,] 1.243e-02 1.243e-02 1.243e-02 1.243e-02 1.243e-02 1.243e-02
## [14,] 9.736e-03 9.736e-03 9.736e-03 9.736e-03 9.736e-03 9.736e-03
## [15,] 8.794e-03 8.794e-03 8.794e-03 8.794e-03 8.794e-03 8.794e-03
## [16,] 6.991e-03 6.991e-03 6.991e-03 6.991e-03 6.991e-03 6.991e-03
## [17,] 3.812e-03 3.812e-03 3.812e-03 3.812e-03 3.812e-03 3.812e-03
## [18,] 3.659e-04 3.659e-04 3.659e-04 3.659e-04 3.659e-04 3.659e-04
## [19,] 1.377e-04 2.304e-10 2.304e-10 2.304e-10 2.304e-10 2.304e-10
## [20,] 2.304e-10 1.377e-04 2.304e-10 2.304e-10 2.304e-10 2.304e-10
## [21,] 2.304e-10 2.304e-10 1.377e-04 2.304e-10 2.304e-10 2.304e-10
## [22,] 2.304e-10 2.304e-10 2.304e-10 1.377e-04 2.304e-10 2.304e-10
## [23,] 2.304e-10 2.304e-10 2.304e-10 2.304e-10 1.377e-04 2.304e-10
## [24,] 2.304e-10 2.304e-10 2.304e-10 2.304e-10 2.304e-10 1.377e-04
```

1.2 Parameter estimation - independent for 15min intervals

Using the package above it is not possible to analyse a multivariate normal distribution with more than 50 variables, hence we continue the analysis with the assumption of independently distributed variables for every 15 minutes.

```
PV1quh<-matrix(rep(0,(744*4)),nrow=31) #quarter hourly values -> take means
for(i in 1:31){
  for (j in 1:(24*4)){
    PV1quh[i,j]<-mean(PV1[i,((j-1)*15+1):(j*15)])
  }
}

estimates_n_ind<-matrix(rep(0,2*96),nrow=2) #under assumption of independence
for (i in 1:(24*4)){
  estimates_n_ind[1,i]<-fitdistr(PV1quh[,i],"normal")$estimate[1] #estimate of mean (mu)
```

```
  estimates_n_ind[2,i]<-fitdistr(PV1quh[,i],"normal")$estimate[2] #estimate of std error (sigma)
  }
estimates_n_ind
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13]
## [1,]    0    0    0    0    0    0    0    0    0     0     0     0     0
## [2,]    0    0    0    0    0    0    0    0    0     0     0     0     0
##      [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24]
## [1,]     0     0     0     0     0     0     0     0     0     0     0
## [2,]     0     0     0     0     0     0     0     0     0     0     0
##      [,25] [,26]  [,27] [,28]  [,29] [,30] [,31] [,32] [,33]  [,34]  [,35]
## [1,]     0     0 0.1239 7.877 127.27 284.8 542.7 742.8 904.3 1011.0 1163.0
## [2,]     0     0 0.2215 4.954  80.92 143.2 206.3 311.8 437.1  377.3  460.8
##       [,36]  [,37]  [,38]  [,39]  [,40]  [,41]  [,42]  [,43]  [,44]  [,45]
## [1,] 1264.7 1400.7 1589.7 1798.8 1774.3 1856.2 1926.0 2187.5 2135.7 2128.6
## [2,]  529.6  585.5  664.9  643.9  662.3  814.7  795.6  784.6  797.5  784.7
##       [,46]  [,47]  [,48]  [,49]  [,50]  [,51]  [,52]  [,53]  [,54]  [,55]
## [1,] 2267.2 2348.1 2304.1 2274.7 2207.5 2184.2 2344.3 2295.1 2170.8 2224.9
## [2,]  835.8  807.5  927.3  933.1  883.6  866.8  862.9  819.1  825.8  664.1
##       [,56]  [,57]  [,58]  [,59]  [,60]  [,61]  [,62]  [,63]  [,64]  [,65]
## [1,] 2156.4 2013.1 1932.2 1873.9 1678.1 1537.3 1376.8 1328.1 1188.2 1047.5
## [2,]  708.6  677.5  669.1  645.3  632.7  638.8  597.6  556.8  518.2  445.6
##      [,66] [,67] [,68] [,69] [,70] [,71] [,72] [,73] [,74] [,75] [,76]
## [1,] 851.5 646.1 408.6 149.9 46.56 16.86 1.836     0     0     0     0
## [2,] 382.4 314.4 234.9 102.4 36.25 18.04 2.952     0     0     0     0
##      [,77] [,78] [,79] [,80] [,81] [,82] [,83] [,84] [,85] [,86] [,87]
## [1,]     0     0     0     0     0     0     0     0     0     0     0
## [2,]     0     0     0     0     0     0     0     0     0     0     0
##      [,88] [,89] [,90] [,91] [,92] [,93] [,94] [,95] [,96]
## [1,]     0     0     0     0     0     0     0     0     0
## [2,]     0     0     0     0     0     0     0     0     0
```

1.3 Sample generation - dependent for 1h intervals

```
# sigma<-estimates_n_dep$sigmahat #24x24 matrix
# mu<-estimates_n_dep$muhat
# A<-chol(sigma)
#
# N<-10000 #sample size
#
# rn<-rep(0,24)
# Nstdsample<-matrix(rep(0,24*N),ncol=24) #matrix to store std norm sample
# for (i in 1:N){
#   rn<-rnorm(24)
#   Nstdsample[i,]<-rn
# }
#
# Nsample<-matrix(rep(0,24*N),ncol=24)#matrix to store N(mu,sigma) sample
# for(i in 1:N){
#   Rea<-rep(0,24)
#   Nstd<-Nstdsample[i,]
#   Rea<-t(A)%*%Nstd+mu
```

```
#   Nsample[i,]<-Rea
# }

N<-1000
Nsample<-mvrnorm(n=N, estimates_n_dep$muhat, estimates_n_dep$sigmahat)


test<-mlest(Nsample)
diffmu<-estimates_n_dep$muhat-test$muhat
diffsigma<-estimates_n_dep$sigmahat-test$sigmahat
max(diffmu)
```

```
## [1] 12.55
```

```
max(diffsigma)
```

```
## [1] 2046
```

1.3 Sample generation - independent for 15min intervals

```
N<-10000
N_ind_sample<-matrix(rep(0,24*4*N), ncol=24*4)
for(i in 1:N){
N_ind_sample[i,]<-rnorm(24*4,estimates_n_ind[1,], estimates_n_ind[2,])
}
```

2. Weibull distribution

3. 1 Parameter estimation - independent for 15min intervals

We assume independently distributed values for every 15 minutes and estimate a and b called the shape parameter and the scale parameter.

```
estimates_w_ind<-matrix(rep(0,2*96),nrow=2) #under assumption of independence
for (i in 1:(24*4)){
  estimates_w_ind[1,i]<-fitdistr(PV1quh[,i],"normal")$estimate[1] #estimate of shape paramter
  estimates_w_ind[2,i]<-fitdistr(PV1quh[,i],"normal")$estimate[2] #estimate of scale parameter
  }
estimates_w_ind
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13]
## [1,]    0    0    0    0    0    0    0    0    0     0     0     0     0
## [2,]    0    0    0    0    0    0    0    0    0     0     0     0     0
##      [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24]
## [1,]     0     0     0     0     0     0     0     0     0     0     0
## [2,]     0     0     0     0     0     0     0     0     0     0     0
##      [,25] [,26]  [,27] [,28]  [,29] [,30] [,31] [,32] [,33]  [,34]  [,35]
## [1,]     0     0 0.1239 7.877 127.27 284.8 542.7 742.8 904.3 1011.0 1163.0
## [2,]     0     0 0.2215 4.954  80.92 143.2 206.3 311.8 437.1  377.3  460.8
```

```
##       [,36]  [,37]  [,38]  [,39]  [,40]  [,41]  [,42]  [,43]  [,44]  [,45]
## [1,] 1264.7 1400.7 1589.7 1798.8 1774.3 1856.2 1926.0 2187.5 2135.7 2128.6
## [2,]  529.6  585.5  664.9  643.9  662.3  814.7  795.6  784.6  797.5  784.7
##       [,46]  [,47]  [,48]  [,49]  [,50]  [,51]  [,52]  [,53]  [,54]  [,55]
## [1,] 2267.2 2348.1 2304.1 2274.7 2207.5 2184.2 2344.3 2295.1 2170.8 2224.9
## [2,]  835.8  807.5  927.3  933.1  883.6  866.8  862.9  819.1  825.8  664.1
##       [,56]  [,57]  [,58]  [,59]  [,60]  [,61]  [,62]  [,63]  [,64]  [,65]
## [1,] 2156.4 2013.1 1932.2 1873.9 1678.1 1537.3 1376.8 1328.1 1188.2 1047.5
## [2,]  708.6  677.5  669.1  645.3  632.7  638.8  597.6  556.8  518.2  445.6
##      [,66] [,67] [,68] [,69] [,70] [,71] [,72] [,73] [,74] [,75] [,76]
## [1,] 851.5 646.1 408.6 149.9 46.56 16.86 1.836     0     0     0     0
## [2,] 382.4 314.4 234.9 102.4 36.25 18.04 2.952     0     0     0     0
##      [,77] [,78] [,79] [,80] [,81] [,82] [,83] [,84] [,85] [,86] [,87]
## [1,]     0     0     0     0     0     0     0     0     0     0     0
## [2,]     0     0     0     0     0     0     0     0     0     0     0
##      [,88] [,89] [,90] [,91] [,92] [,93] [,94] [,95] [,96]
## [1,]     0     0     0     0     0     0     0     0     0
## [2,]     0     0     0     0     0     0     0     0     0
```