

PV data - Parameter estimation

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```
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

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

estimates_n_dep$muhat
```

```
## [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
```

```
##          [,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
```

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
```

2. Weibull distribution

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

```