The Merit Order Effect in the German Power Market

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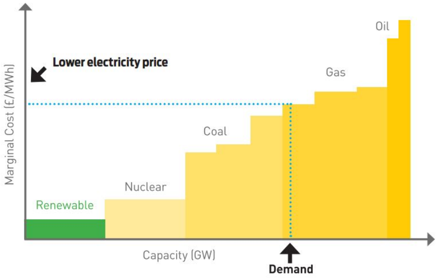
Statistical Programming Languages
https://github.com/mpff/spl2018-bfm

Motivation

We want to measure the merit order effect for the German power market, based on Clò, Cataldi, and Zoppoli 2015.



Regression

Regression equation:

$$\text{price} = \beta_0 + \beta_1 \cdot \text{dem} + \beta_2 \cdot \text{wind} + \beta_3 \cdot \text{solar} + \gamma \cdot \text{ymd} + \epsilon \qquad (1)$$

price:	Mean daily day ahead price
dem:	Forecasted daily demand
solar:	Forecasted daily electricity production from solar
wind:	Forecasted daily electricity production from wind
ymd:	Year, month, day dummies

Data Sources

price: Day Ahead Price, seit 2011 (Elspot Prices Data).

dem: Day Ahead Demand, seit 2015, DE+AT+LUX (entsoe)

solar: Day Ahead Prognose, seit 2012, DE (netztransparenz.de)
Day Ahead Prognose, seit 2015, AT (apg.at)

wind: Day Ahead Prognose, seit 2012, DE (netztransparenz.de)
Day Ahead Prognose, seit 2015, AT (apg.at)

Probleme:

1. Unterschiedliche Zeitspannen und -auflösungen.
2. NA's erschweren Bildung von täglichen Mittel-/Gesamtwerten.
3. Luxemburg im Demand ein (großes) Problem? Price einheitlich in DE+AT?

Data Cleaning

```
df.pun.0 <- read.csv("source/Elspot_xxx.csv")
df.pun <- subset(df.pun.0, select = c(HourUTC,
SpotPriceEUR))
colnames(df.pun) = c("TIME", "PUN")
df.pun$TIME <- ymd_hm(df.pun$TIME)
df.pun <- time.FRAME(df.pun)
df.pun <- aggregate(list("PUN" = df.pun$PUN),
list("TIME" = cut(df.pun$TIME, "1 day")), FUN = mean)
...
# Bind final Dataframe
df <- cbind(df.pun, df.dm, df.solar, df.wind)
```

Exploratory Analysis

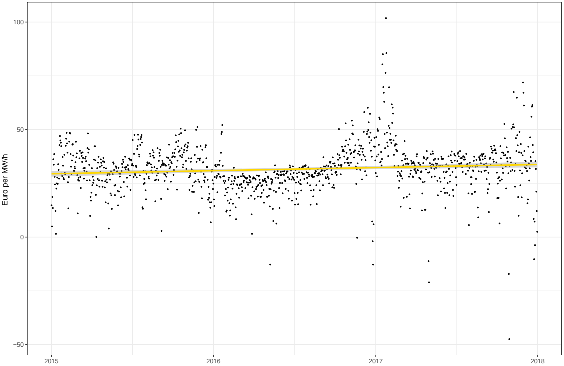


Figure 1: Day-Ahead Price

Exploratory Analysis

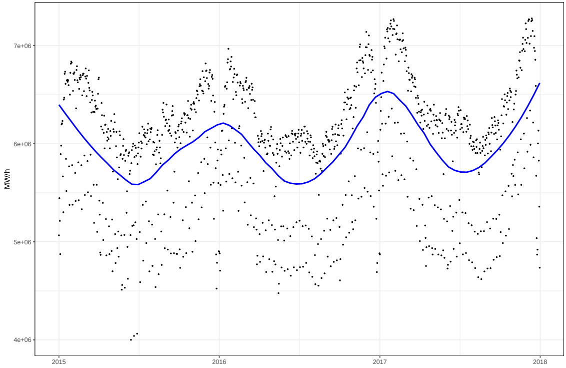


Figure 2: Day-Ahead Demand

Exploratory Analysis

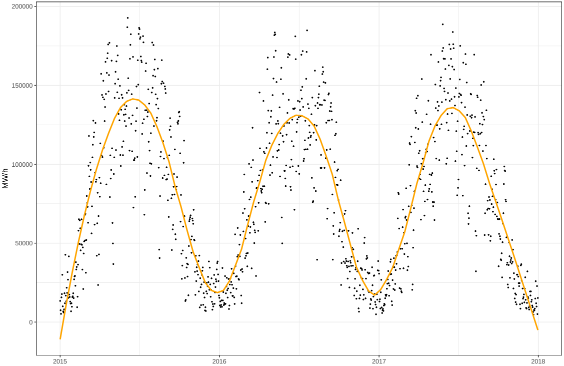


Figure 3: Day-Ahead Solar Production

Exploratory Analysis

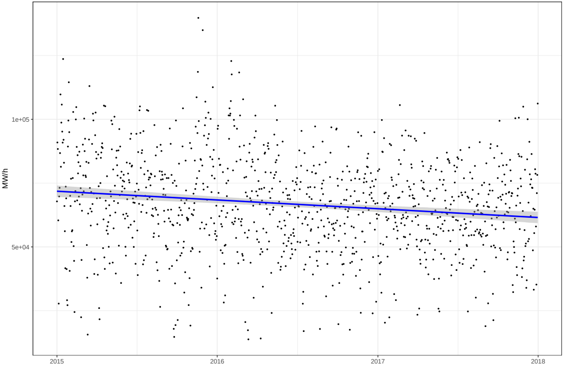


Figure 4: Day-Ahead Wind Production

Exploratory Analysis

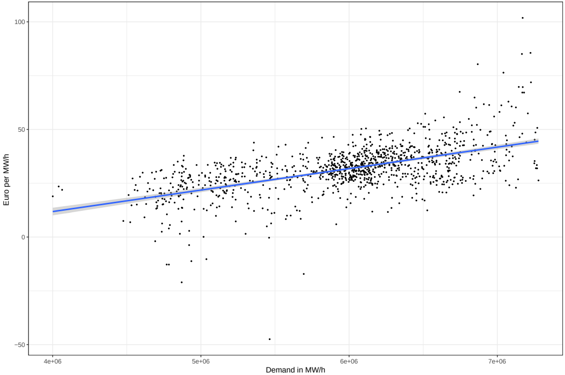


Figure 5: Price on Demand

Exploratory Analysis

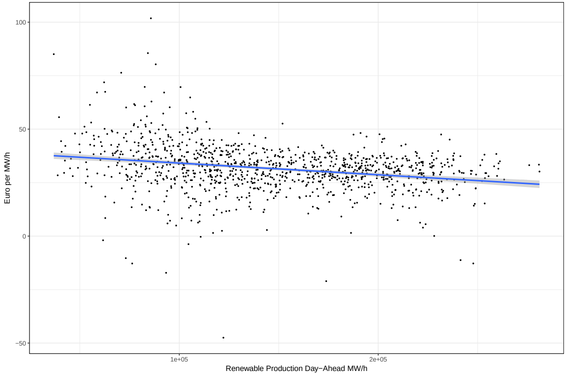


Figure 6: Day-Ahead Price on Renewables Production

Problems with Missing Values

Interpolation

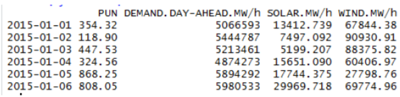
Function for removing missing values
Example function: `x[i] <- mean(x[(i-1):(i+1)]`

- input - numerical vector and index of missing values
- computes mean of values next to missing value
- output - numerical vector without missing values

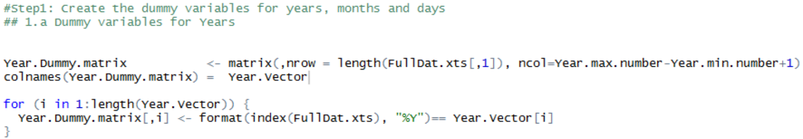
Alternative: Use time "based" interpolation

- Is missing values problem big?
- Otherwise keep missing Values?
- here insert Manus graph with NAs? or felix results from NA regression..

Time-Dummy generating function:



```
                 PUN DEMAND.DAY-AHEAD.MW/h SOLAR.MW/h WIND.MW/h
2015-01-01 354.32                  5066593  13412.739  67844.38
2015-01-02 118.90                  5444787   7497.092  90930.91
2015-01-03 447.53                  5213461   5199.207  88375.82
2015-01-04 324.56                  4874273  15651.090  60406.97
2015-01-05 868.25                  5894292  17744.375  27798.76
2015-01-06 808.05                  5980533  29969.718  69774.96
```



```
#Step1: Create the dummy variables for years, months and days
## 1.a Dummy variables for Years


Year.Dummy.matrix            <- matrix(,nrow = length(FullDat.xts[,1]), ncol=Year.max.number-Year.min.number+1)
colnames(Year.Dummy.matrix) =  Year.Vector

for (i in 1:length(Year.Vector)) {
  Year.Dummy.matrix[,i] <- format(index(FullDat.xts), "%Y")== Year.Vector[i]
}
```

- Creates a dummy matrix for: year, month, day o.t. week.
- Function adapts the amount of years directly from the data.
- y/m/d to be omitted, bc. of the dummy variable trap, can be specified.

Regression and Tests

$$\text{price} = \beta_0 + \beta_1 \cdot \text{dem} + \beta_2 \cdot \text{wind} + \beta_3 \cdot \text{solar} + \gamma \cdot \text{ymd} + \epsilon$$

Step 1: Check for stationarity of the variables (augmented dickey fuller Test) → All variables stationary except solar.

Step 2: Perform the OLS regression.

Step 3: Check for Heteroscedasticity and Autocorrelation.
→ Breusch-Pagan Test for heteroscedasticity.
→ Durbin-Watson test for autocorrelation.
→ Plot the autocorrelation structure.

Step 4: If okay [AR(1)], use the Prais-Winsten generalized estimation method.

Step 5: Check the new autocorrelation structure.

Regression and Tests

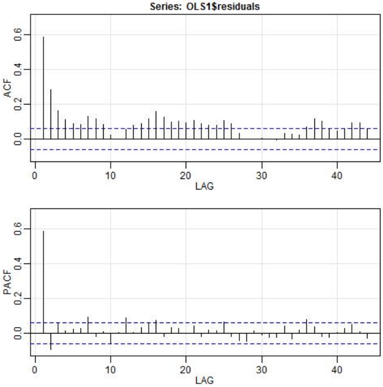


Figure 7: **OSL, ACF and PACF** Autocorrelation = TRUE (durbin-watson)

Regression and Tests

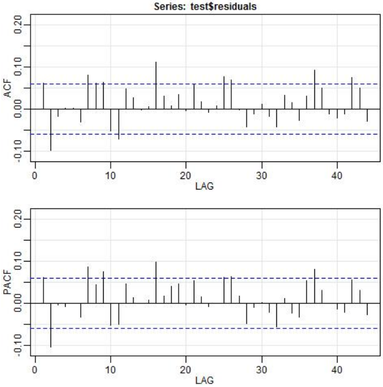
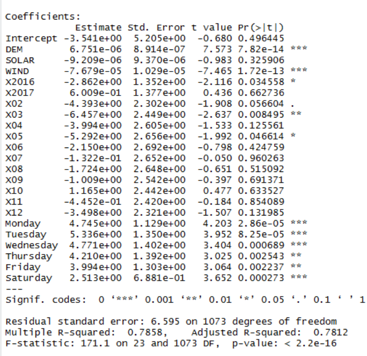


Figure 8: **Prais-Winsten, ACF and PACF**

Regression and Tests

$$\text{price} = \beta_0 + \beta_1 \cdot \text{dem} + \beta_2 \cdot \text{wind} + \beta_3 \cdot \text{solar} + \gamma \cdot \text{ymd} + \epsilon$$



```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
Intercept -3.541e+00  5.205e+00  -0.680 0.496445
DEM        6.751e-06  8.914e-07   7.573 7.82e-14 ***
SOLAR     -9.209e-06  9.370e-06  -0.983 0.325906
WIND      -7.679e-05  1.029e-05  -7.465 1.72e-13 ***
X2016     -2.862e+00  1.352e+00  -2.116 0.034558 *
X2017      6.009e-01  1.377e+00   0.436 0.662736
X02       -4.393e+00  2.302e+00  -1.908 0.056604 .
X03       -6.457e+00  2.449e+00  -2.637 0.008495 **
X04       -3.994e+00  2.605e+00  -1.533 0.125561
X05       -5.292e+00  2.656e+00  -1.992 0.046614 *
X06       -2.150e+00  2.692e+00  -0.798 0.424759
X07       -1.322e-01  2.652e+00  -0.050 0.960263
X08       -1.724e+00  2.648e+00  -0.651 0.515092
X09       -1.009e+00  2.542e+00  -0.397 0.691371
X10        1.165e+00  2.442e+00   0.477 0.633527
X11       -4.452e-01  2.420e+00  -0.184 0.854089
X12       -3.498e+00  2.321e+00  -1.507 0.131985
Monday     4.745e+00  1.129e+00   4.203 2.86e-05 ***
Tuesday    5.336e+00  1.350e+00   3.952 8.25e-05 ***
Wednesday  4.771e+00  1.402e+00   3.404 0.000689 ***
Thursday   4.210e+00  1.392e+00   3.025 0.002543 **
Friday     3.994e+00  1.303e+00   3.064 0.002237 **
Saturday   2.513e+00  6.881e-01   3.652 0.000273 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 6.595 on 1073 degrees of freedom
Multiple R-squared:  0.7858,    Adjusted R-squared:  0.7812
F-statistic: 171.1 on 23 and 1073 DF,  p-value: < 2.2e-16
```

Figure 9: **Prais-Winsten**

Unsere Fragen

Wie soll mit den Missing Values umgegangen werden?
Wie sollen wir unser Programm testen?