

# Modeling and forecasting of electricity prices and demand

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## **Abstract**

Goal of the thesis is to test models for demand and price forecasting for Danish day-ahead power market using regression method. Suggested models include expert models using different variables and different sets of rolling window and transformation method.

Keywords: electricity spot prices, day-ahead market, forecasting, power market  
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# 1 Introduction

We have experienced big growth of wind power industry in the recent years and massive number of new installments of the wind turbines. Some countries have significantly increasing shares of renewable energy in the overall production. I will focus especially on a wind energy, which is becoming the most important source in some regions.

Better prognosis of the renewable energy production, consumption may have positive impact on the final predicted price of energy. Smaller errors may lead to economical profits for companies operating and buying energy on the power exchanges.

In this work I made a simulations in order to achieve the best forecasts of consumption and price for Danish market using day-ahead data. There are plenty of possible approaches using, i.e. regression models[13][10], neural networks[6][14], probabilistic methods[9]. I decided to use regression model with best fitting expert models from [2] implementing modifications of HP filter and testing different variations of expert models with different lengths of calibration window.

In the Chapter 2 I reviewed analysis of the Danish market. In the Chapter 3 I presented characteristics of available data provided by Nordpool power exchange. In the Chapter 4 I presented used methods to perform forecasts. In the Chapter 5 I presented empirical results of the all forecasts and in the last Chapter 6 I came up with conclusions.

# 2 Market analysis

Danish power market has been transformed in the last several years drastically. Since 70s there was a lot of investments in renewable sources of energy, especially in the field of wind power, and much more since 2002 when first large scale offshore wind farm in the world has been finished - Horns Rev 1 (160 MW). For year 2019, total wind power generation capacity was 6128 MW[7].

National target for 2020 is over 50% of a energy consumption covered by wind power and it's likely to be achieved, as in 2019 they obtained 47% of coverage by domestic production[3]. Moreover they have finished construction of next large scale wind farm Horns Rev 3 in August 2019[3]. There are also defined next goals in last presented national energy strategy. For wind power consumption they aim for 70% in 2030[3]. Denmark is currently leader of wind power shares in the national production and its development.

The production of such significant part of energy from wind carries some risk. Wind speed is very fluctuant and variable even in a day cycle. There are no perfect methods of forecasting in the long term periods. It may occur in higher (or lower) demand in production from other, stable sources of energy to cover consumption. It's problematic to mark a common trend in wind power forecasts<sup>1</sup>. Thus it's helpful to correct prediction of electricity demand.

Wind power generation can't be stopped quickly as production of conventional

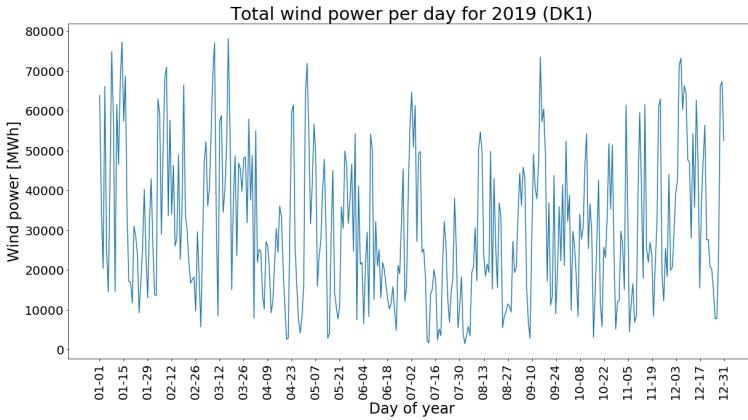


Figure 1: Wind power produced per day in 2019 (DK1)

sources of energy (coal, gas). Because of that higher unexpected wind power production may lead to decreased prices on energy stocks and in some cases, prices can drop below zero. That was happening rarely in the era of conventional production and regulated electricity market, but it happens more often with more renewable power generators. Because energy network is quite connected with each other in the European Union, in a case of negative prices energy from Danish areas (DK1, DK2) is exported to the neighboring countries, mainly to the Germany, which Denmark has the biggest balance of energy export and import.

Negative prices obligate to use other approaches of price forecasting, than the old ones which were failing with unexpected domain of values. In my work I will present a few models to forecast price and consumption and point out the best approach to have optimal forecasts.

The electricity market in Denmark is divided into 2 areas (DK1 and DK2). First area (DK1) consists of regions: Nordjylland, Midtjylland and Syddanmark; second area (DK2) consists of regions Sjælland and Hovedstaden with the capital Copenhagen.



Figure 2: Danish electricity market

### 3 Data analysis

Data I used to perform forecasts has been downloaded from the official webpage of the Nordpool power exchange[5]. Datasets are divided into the year files and periods (hours, weeks etc.). I managed to download following datasets (valid for the day 14.05.2020):

- Consumption - hourly
- Consumption prognosis - hourly
- Wind power - hourly
- Wind power prognosis - hourly
- Elspot prices (as Price) - hourly

All of the datasets were available for years 2013-2020, except for Consumption prognosis (2015-2020). So I decided to focus on analysis only on the period 2015-2020 (2015.01.01-2020.05.12), because 4 years time frame is still sufficient for calculations.

Units of downloaded data are following:

- Consumption and Wind Power- MWh
- Price - DKK/MWh

The files were downloaded, merged, split for regions DK1 and DK2, pivoted in order to have separated hours as parameters for each day and merged for all years. Example for consumption DK1 is presented below.

I performed a few analysis for each dataset, although I didn't include all of the charts and the tables in this work. The rest is uploaded into the github repository.

|   | date       | holiday | 0      | 1      | 2      | ... | 22     | 23     |
|---|------------|---------|--------|--------|--------|-----|--------|--------|
| 0 | 2016-01-01 | 1       | 1818.0 | 1741.0 | 1660.0 | ... | 1858.0 | 1713.0 |
| 1 | 2016-01-02 | 0       | 1615.0 | 1510.0 | 1461.0 | ... | 2027.0 | 1822.0 |
| 2 | 2016-01-03 | 1       | 1724.0 | 1665.0 | 1671.0 | ... | 2127.0 | 1998.0 |
| 3 | 2016-01-04 | 0       | 1844.0 | 1803.0 | 1789.0 | ... | 2293.0 | 2079.0 |
| 4 | 2016-01-05 | 0       | 1940.0 | 1891.0 | 1952.0 | ... | 2372.0 | 2193.0 |

Table 1: First 5 rows of merged file Consumption DK1.

### 3.1 Missing values

Data was very consistent and yet only single values were missing. These null values were replaced by average of the neighboring cells and in case of missing value in neighbor cell, value was fixed manually (with file `fill_empty_cells.py`). Half of day 2018-09-18 from Wind prognosis files was filled taking closest neighbors and counting average for whole vector (with file `fill_empty_cells_wind_prognosis_DK.py`). Number of missing values was reduced to zero.

| Dataset               | DK1 | DK2 |
|-----------------------|-----|-----|
| Consumption           | 5   | 5   |
| Consumption prognosis | 5   | 5   |
| Price                 | 21  | 12  |
| Wind power            | 12  | 6   |
| Wind power prognosis  | 18  | 19  |

Table 2: Missing values in files.

### 3.2 Consumption data

Electricity consumption was higher in the area DK1 than DK2, compared for years 2016-2019 19.14, 19.41, 20.28, 20.37 TWh to 13.13, 13.03, 13.28, 13.16 TWh accordingly. We can see that consumption increased gradually in the area DK1, meanwhile in area DK2 was on the similar level.

We can spot three types of seasonal trends in the data: annual, weekly and daily. On the below chart showing consumption per day in 2019, we see that every weekend consumption value drops.

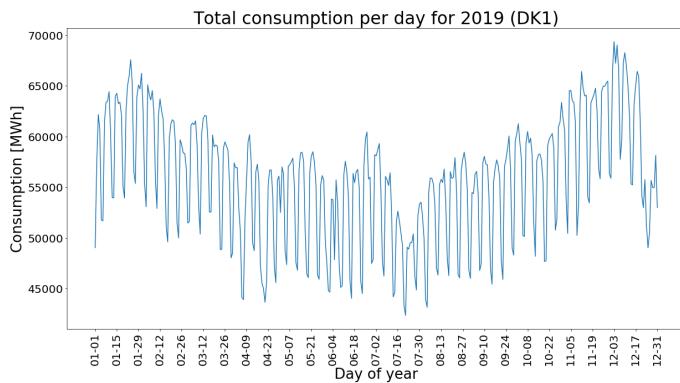


Figure 3: Consumption per day in 2019 (DK1)

Although it's not easy to spot in the DK1, there is annual trend with lower consumption during summer months and higher during winter. It's observable particularly in the DK2.

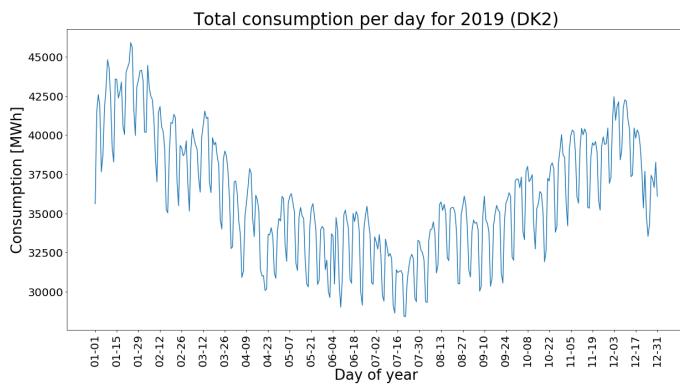


Figure 4: Consumption per day in 2019 (DK2)

Simple moving average with 14 days windows for each year shows clearly this trend. Although in the area DK1 it's not very sharp.

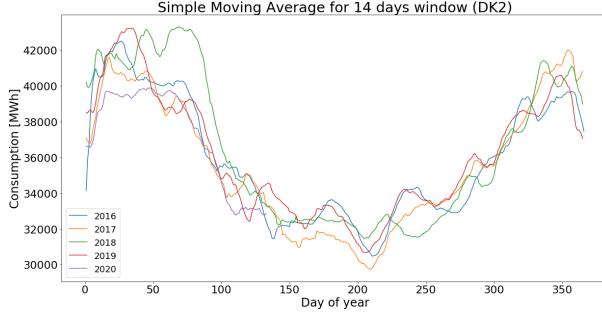


Figure 5: Simple moving average of consumption - 14 days window (DK2)

Last seasonal trend is daily which can be observed for each day of a week, even holidays. There are two peaks of energy consumption each day, in the morning and evening. During weekends and holidays, morning peaks are slightly shifted than during work days. There is also noticeable smaller consumption in the night.

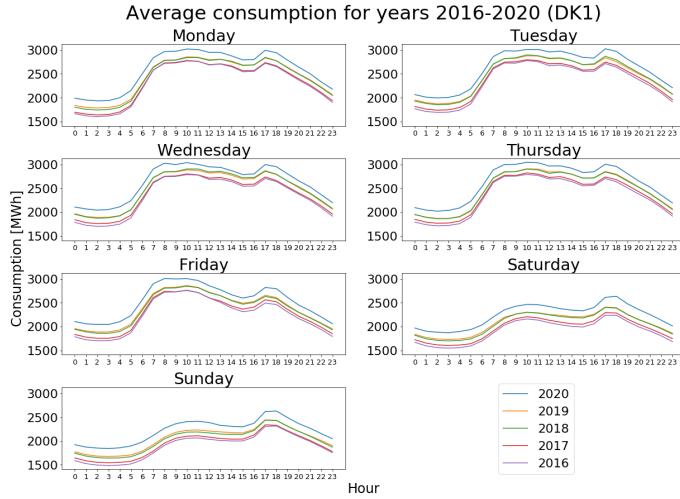


Figure 6: Average consumption per each hour of day for each day of week (DK1)

There is also one interesting thing observed in the 2020's data only in the area DK2. Evening daily peak is slightly shifted which can be caused epidemic COVID-19 or incomplete data of 2020 year.

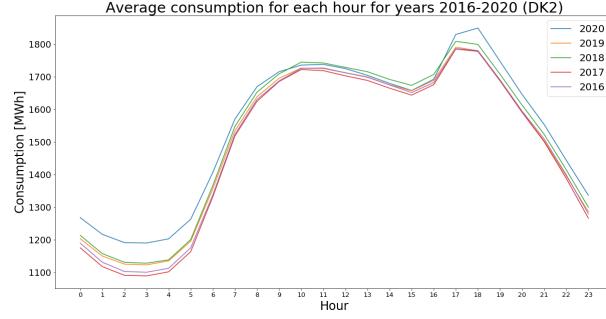


Figure 7: Average consumption per each hour of day for each year (DK2)

### 3.2.1 Nordpool's prognosis

The prognosis day-ahead given by Nordpool shows that those are less accurate over time, especially for area DK1 where consumption is larger than DK2. Level of accuracy for area DK2 is quite stable. Also there is no clear trend regarding the time of day. For DK1 best prediction are for night and for DK2 best prediction are performed for hours 7 and 15.

| Area | Year  | 0    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14   | 15   | 16   | 17   | 18   | 19   | 20   | 21   | 22   | 23   | Total |
|------|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------|
| DK1  | 2016  | 18.7 | 15.2 | 13.2 | 12.7 | 12.3 | 14.1 | 18.7 | 19.5 | 20.3 | 19.6 | 19.6 | 19.7 | 20.4 | 19.0 | 16.5 | 16.9 | 16.0 | 18.7 | 17.7 | 15.9 | 16.0 | 15.0 | 13.7 | 17.3 | 16.9  |
|      | 2017  | 16.1 | 24.9 | 19.0 | 13.9 | 14.1 | 15.1 | 18.7 | 18.7 | 19.1 | 19.9 | 19.8 | 17.8 | 16.3 | 15.4 | 15.1 | 16.1 | 21.1 | 22.1 | 20.7 | 17.2 | 18.0 | 17.5 | 19.4 | 22.5 | 18.3  |
|      | 2018  | 18.8 | 26.7 | 17.7 | 15.9 | 14.1 | 15.9 | 20.6 | 24.8 | 21.0 | 23.6 | 21.3 | 20.1 | 22.5 | 21.0 | 20.9 | 19.8 | 19.2 | 21.7 | 18.3 | 19.9 | 24.9 | 22.5 | 23.1 | 25.8 | 20.8  |
|      | 2019  | 22.0 | 29.3 | 21.8 | 17.9 | 17.2 | 18.1 | 23.0 | 24.9 | 22.0 | 27.3 | 24.7 | 22.7 | 23.0 | 20.6 | 19.2 | 19.2 | 20.2 | 21.5 | 22.6 | 22.4 | 25.2 | 24.0 | 25.1 | 30.3 | 22.7  |
|      | 2020  | 21.7 | 26.9 | 23.4 | 20.5 | 16.8 | 20.5 | 34.8 | 34.2 | 26.4 | 32.8 | 32.9 | 22.6 | 22.2 | 27.4 | 24.6 | 22.2 | 22.3 | 36.1 | 32.4 | 23.6 | 26.4 | 24.5 | 27.7 | 32.4 | 26.5  |
|      | Total | 19.1 | 24.3 | 18.4 | 15.5 | 14.6 | 16.2 | 21.4 | 23.0 | 21.1 | 23.5 | 22.3 | 20.3 | 20.7 | 19.7 | 18.5 | 18.3 | 19.4 | 22.2 | 20.9 | 19.2 | 21.5 | 20.1 | 20.9 | 24.7 | 20.2  |

Figure 8: MAE for consumption for each hour and year with total figures (DK1)

| Area | Year  | 0    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14   | 15   | 16   | 17   | 18   | 19   | 20   | 21   | 22   | 23   | Total |
|------|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------|
| DK2  | 2016  | 23.8 | 19.6 | 19.0 | 20.3 | 22.4 | 22.9 | 20.9 | 17.1 | 23.6 | 27.6 | 24.3 | 21.4 | 24.1 | 22.0 | 20.0 | 19.2 | 23.3 | 26.4 | 24.5 | 22.9 | 24.5 | 24.6 | 20.7 | 15.9 | 22.1  |
|      | 2017  | 19.6 | 21.9 | 21.7 | 20.2 | 18.8 | 18.5 | 22.7 | 16.8 | 20.2 | 21.8 | 21.6 | 20.8 | 20.2 | 20.5 | 20.6 | 16.7 | 18.0 | 24.4 | 23.3 | 21.2 | 20.8 | 22.8 | 22.8 | 27.4 | 21.0  |
|      | 2018  | 18.1 | 25.2 | 24.7 | 20.8 | 19.5 | 20.2 | 27.5 | 18.8 | 21.2 | 24.8 | 26.8 | 26.7 | 27.0 | 26.1 | 22.4 | 17.5 | 20.7 | 24.7 | 22.5 | 22.4 | 26.8 | 29.1 | 25.9 | 23.2 | 23.4  |
|      | 2019  | 16.1 | 23.9 | 22.8 | 17.5 | 16.3 | 15.9 | 21.2 | 14.3 | 16.9 | 17.9 | 21.2 | 21.6 | 18.6 | 17.5 | 17.1 | 15.3 | 18.7 | 24.5 | 22.1 | 18.8 | 22.2 | 22.6 | 21.1 | 22.7 | 19.5  |
|      | 2020  | 17.4 | 18.2 | 15.8 | 12.4 | 15.0 | 17.6 | 25.5 | 22.1 | 24.4 | 31.0 | 36.4 | 27.6 | 23.5 | 26.0 | 21.7 | 13.9 | 15.9 | 28.1 | 27.5 | 18.3 | 17.2 | 17.1 | 14.6 | 18.9 | 21.1  |
|      | Total | 19.2 | 22.3 | 21.5 | 19.1 | 18.9 | 19.2 | 23.3 | 17.2 | 20.8 | 23.7 | 24.5 | 23.0 | 22.6 | 21.9 | 20.1 | 16.9 | 19.8 | 25.3 | 23.5 | 21.1 | 23.1 | 24.1 | 22.0 | 22.0 | 21.5  |

Figure 9: MAE for consumption for each hour and year with total figures (DK2)

### 3.3 Wind power data

Wind power production increased significantly within last 4 years. In the area DK1 from 9.41 to 11.26 TWh and for area DK2 from 2.37 to 3.22 TWh, so about 35% more.

So far in the consumption data we could spot trends whereas in the wind power data there is no distinct trend.

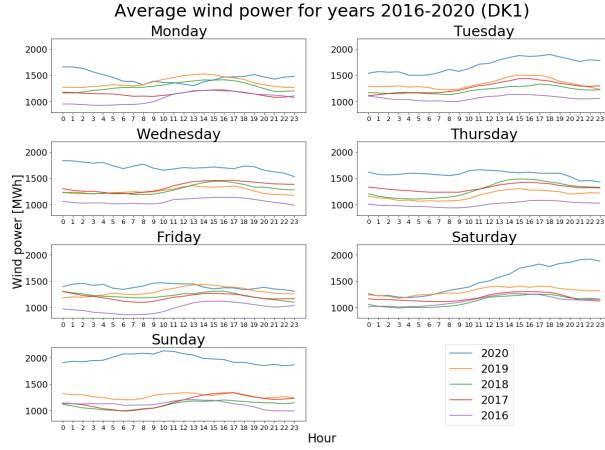


Figure 10: Wind power production per hour of a day for each day of week (DK1)

Simple moving average also doesn't show anything recurrent, thus we can't assume any annual trend.

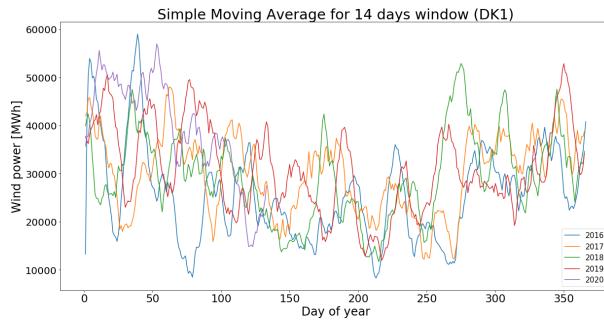


Figure 11: Simple moving average of wind power production for each day of the year (DK1)

Only chart of average wind power for each hour suggest there may be a daily trend, however data from area DK2 doesn't confirm this assumption.

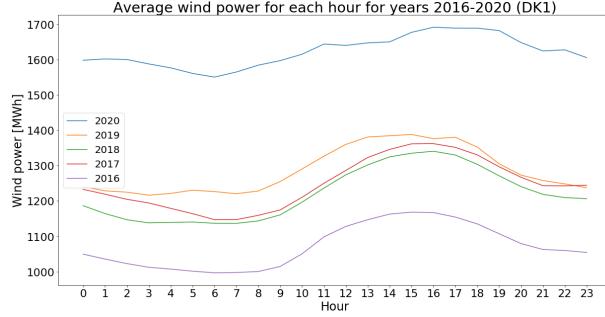


Figure 12: Average wind power production per hour of a day for each year (DK1)

### 3.3.1 Nordpool's prognosis

I calculated mean absolute error for prognosis performed by Nordpool for each hour and year. The results for area DK1 are rounded to the whole number. We can spot that error for prognosis is bigger for newer data with over 80% growth in 2020 (until 12th May) comparing to the previous year. Another thing we can notice that the error in the night hours is lower than others.

|      | 0     | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  | 20  | 21  | 22  | 23  | Total |     |
|------|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|-----|
| Area | Year  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |       |     |
|      | 2016  | 125 | 131 | 133 | 134 | 141 | 145 | 144 | 152 | 155 | 157 | 164 | 163 | 163 | 180 | 191 | 194 | 189 | 189 | 187 | 189 | 185 | 186 | 182 | 180   | 165 |
|      | 2017  | 152 | 156 | 161 | 158 | 162 | 166 | 167 | 170 | 169 | 168 | 183 | 196 | 197 | 198 | 199 | 202 | 204 | 202 | 197 | 194 | 194 | 195 | 199 | 200   | 183 |
|      | 2018  | 154 | 149 | 150 | 156 | 155 | 156 | 162 | 162 | 174 | 175 | 184 | 186 | 192 | 201 | 209 | 217 | 225 | 215 | 207 | 211 | 208 | 207 | 210 | 227   | 187 |
|      | 2019  | 216 | 216 | 208 | 213 | 217 | 219 | 221 | 217 | 218 | 217 | 226 | 229 | 238 | 249 | 253 | 255 | 261 | 255 | 256 | 241 | 232 | 240 | 246 | 258   | 233 |
|      | 2020  | 410 | 379 | 381 | 389 | 401 | 400 | 425 | 411 | 381 | 382 | 386 | 404 | 431 | 429 | 451 | 447 | 484 | 470 | 432 | 424 | 437 | 455 | 449 | 462   | 422 |
|      | Total | 182 | 181 | 181 | 184 | 188 | 191 | 194 | 195 | 196 | 196 | 205 | 211 | 217 | 225 | 233 | 236 | 242 | 236 | 230 | 227 | 224 | 227 | 229 | 237   | 211 |

Figure 13: MAE for wind power and Nordpool prognosis for each hour and year (DK1)

The results for area DK2 are similar, however numbers are smaller due to the lower capacity of wind farms in this part of Denmark.

|      | 0     | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14   | 15   | 16   | 17   | 18   | 19   | 20   | 21   | 22   | 23   | Total |      |
|------|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------|------|
| Area | Year  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |      |
|      | 2016  | 45.7 | 45.7 | 45.9 | 45.0 | 47.4 | 48.7 | 50.3 | 51.5 | 50.6 | 49.1 | 49.6 | 52.2 | 49.6 | 49.9 | 51.5 | 51.3 | 53.2 | 58.0 | 60.8 | 59.4 | 59.4 | 60.7 | 65.5 | 66.1  | 52.8 |
|      | 2017  | 55.5 | 57.4 | 57.1 | 56.5 | 53.7 | 54.7 | 56.0 | 56.3 | 59.7 | 60.0 | 62.2 | 65.0 | 67.9 | 70.0 | 67.1 | 68.9 | 68.2 | 68.8 | 70.1 | 72.6 | 72.2 | 70.4 | 68.3 | 69.3  | 63.7 |
|      | 2018  | 52.5 | 54.2 | 53.9 | 54.1 | 55.2 | 56.4 | 56.2 | 59.5 | 60.7 | 60.1 | 60.1 | 62.5 | 60.9 | 59.2 | 59.8 | 65.1 | 67.3 | 73.6 | 75.4 | 70.7 | 70.9 | 68.5 | 66.6 | 69.6  | 62.2 |
|      | 2019  | 58.4 | 60.0 | 56.5 | 58.1 | 55.2 | 55.1 | 56.7 | 60.3 | 64.2 | 62.9 | 66.3 | 67.7 | 65.9 | 65.1 | 63.5 | 64.9 | 67.6 | 69.6 | 71.0 | 68.6 | 67.9 | 72.4 | 73.6 | 73.4  | 64.4 |
|      | 2020  | 68.6 | 66.1 | 65.7 | 67.2 | 66.7 | 66.6 | 64.3 | 63.7 | 61.1 | 72.8 | 73.0 | 70.1 | 74.4 | 79.9 | 78.6 | 76.9 | 87.7 | 84.3 | 78.0 | 76.6 | 82.5 | 87.8 | 89.8 | 96.0  | 74.9 |
|      | Total | 54.3 | 55.3 | 54.4 | 54.6 | 54.0 | 54.8 | 55.6 | 57.5 | 59.0 | 59.3 | 60.7 | 62.5 | 62.2 | 62.6 | 62.0 | 63.7 | 66.0 | 68.9 | 70.0 | 68.5 | 68.8 | 69.7 | 70.3 | 71.8  | 61.9 |

Figure 14: MAE for wind power and Nordpool prognosis for each hour and year (DK2)

### 3.4 Price data

In the 2020 price of energy decreased compared to the previous years. However we don't know what kind of the impact had epidemic on this data so it's hard to come up

with any conclusion.

| Year | DK1     | DK2     |
|------|---------|---------|
| 2016 | 184.435 | 206.825 |
| 2017 | 224.005 | 227.575 |
| 2018 | 329.235 | 339.345 |
| 2019 | 289.270 | 295.390 |
| 2020 | 142.520 | 149.865 |

Table 3: Average price of energy per each year (DKK/MWh)

As in the consumption data we can also notice seasonal trends in this category, but this time only two kinds: daily and weekly. There is no annual trend in the price data.

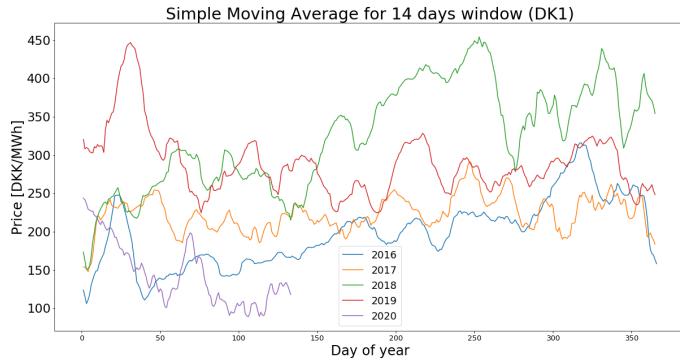


Figure 15: Simple moving average of price for each year - 14 days window (DK1)

Electricity prices are lower during weekends due to the lower consumption and there are also 2 daily peaks each day, either weekend (including holidays) and work days.

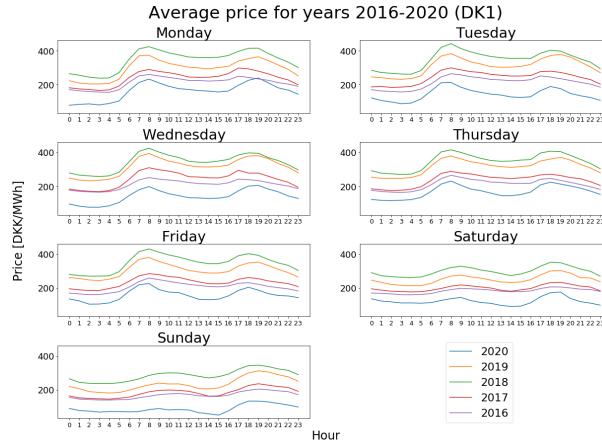


Figure 16: Average price per hour of a day for each day of week (DK1)

### 3.4.1 Negative prices

There were 417 negative prices in the area DK1 in the years 2016-2020 and 288 in the DK2. The dataset for 2020 ends on 12th May, however there are already 84 negative prices compared to the 133 in the full year 2019. Negative prices occur more often during nights than the peaks of consumption. It shows that DK2 is more balanced than DK1.

|       | 0  | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | Total |
|-------|----|----|----|----|----|----|----|----|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-------|
| year  |    |    |    |    |    |    |    |    |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |       |
| 2016  | 3  | 7  | 8  | 8  | 6  | 4  | 5  | 2  | 1 | 1 | 0  | 0  | 1  | 2  | 3  | 2  | 2  | 1  | 0  | 0  | 1  | 2  | 0  | 4  | 63    |
| 2017  | 6  | 6  | 8  | 7  | 6  | 5  | 6  | 4  | 1 | 2 | 2  | 2  | 2  | 4  | 4  | 5  | 4  | 0  | 0  | 0  | 1  | 3  | 3  | 4  | 85    |
| 2018  | 4  | 5  | 5  | 6  | 7  | 6  | 6  | 3  | 0 | 0 | 1  | 0  | 1  | 2  | 2  | 1  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 2  | 52    |
| 2019  | 9  | 9  | 12 | 14 | 11 | 5  | 6  | 4  | 3 | 3 | 4  | 3  | 6  | 9  | 11 | 8  | 4  | 2  | 1  | 1  | 1  | 1  | 1  | 5  | 133   |
| 2020  | 5  | 3  | 6  | 7  | 7  | 7  | 4  | 3  | 2 | 2 | 4  | 3  | 3  | 4  | 6  | 7  | 6  | 1  | 1  | 0  | 0  | 1  | 1  | 1  | 84    |
| Total | 27 | 30 | 39 | 42 | 37 | 27 | 27 | 16 | 7 | 8 | 11 | 8  | 13 | 21 | 26 | 23 | 16 | 4  | 2  | 1  | 3  | 8  | 5  | 16 | 417   |

Figure 17: Number of negative prices for each hour, year and totally (DK1)

### 3.4.2 Correlation between price and wind power

We can suspect that with bigger values of wind power price is lower. Pearson's correlation shows that mostly it's weak correlation, only for 2020 year there are moderate values.

Correlation is a little bit higher for night hours than rest of the day.

| Area | Year | 0     | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 11    | 12    | 13    | 14    | 15    | 16    | 17    | 18    | 19    | 20    | 21    | 22    | 23    |       |
|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|      | 2016 | -0.41 | -0.42 | -0.41 | -0.41 | -0.40 | -0.36 | -0.36 | -0.40 | -0.44 | -0.44 | -0.42 | -0.41 | -0.40 | -0.39 | -0.38 | -0.37 | -0.37 | -0.35 | -0.35 | -0.41 | -0.43 | -0.38 | -0.37 | -0.37 | -0.37 |
|      | 2017 | -0.62 | -0.62 | -0.61 | -0.58 | -0.54 | -0.52 | -0.46 | -0.46 | -0.51 | -0.53 | -0.53 | -0.55 | -0.56 | -0.54 | -0.53 | -0.51 | -0.50 | -0.51 | -0.60 | -0.63 | -0.62 | -0.60 | -0.62 | -0.61 |       |
| DK1  | 2018 | -0.45 | -0.46 | -0.49 | -0.50 | -0.48 | -0.44 | -0.36 | -0.38 | -0.42 | -0.44 | -0.46 | -0.45 | -0.43 | -0.41 | -0.40 | -0.39 | -0.42 | -0.41 | -0.45 | -0.46 | -0.44 | -0.46 | -0.47 | -0.48 |       |
|      | 2019 | -0.50 | -0.50 | -0.52 | -0.53 | -0.51 | -0.46 | -0.37 | -0.38 | -0.39 | -0.41 | -0.42 | -0.41 | -0.40 | -0.38 | -0.35 | -0.33 | -0.34 | -0.40 | -0.51 | -0.56 | -0.56 | -0.56 | -0.56 | -0.56 |       |
|      | 2020 | -0.53 | -0.63 | -0.81 | -0.84 | -0.83 | -0.83 | -0.72 | -0.68 | -0.69 | -0.69 | -0.68 | -0.64 | -0.68 | -0.69 | -0.72 | -0.74 | -0.75 | -0.73 | -0.72 | -0.72 | -0.69 | -0.65 | -0.69 | -0.73 |       |
|      | 2016 | -0.36 | -0.40 | -0.41 | -0.40 | -0.34 | -0.29 | -0.27 | -0.23 | -0.25 | -0.25 | -0.25 | -0.25 | -0.25 | -0.25 | -0.25 | -0.23 | -0.18 | -0.19 | -0.24 | -0.28 | -0.31 | -0.31 | -0.28 | -0.32 |       |
|      | 2017 | -0.61 | -0.61 | -0.61 | -0.61 | -0.57 | -0.50 | -0.45 | -0.42 | -0.42 | -0.43 | -0.44 | -0.46 | -0.44 | -0.43 | -0.42 | -0.38 | -0.37 | -0.37 | -0.42 | -0.47 | -0.53 | -0.58 | -0.62 | -0.63 |       |
| DK2  | 2018 | -0.52 | -0.53 | -0.53 | -0.53 | -0.51 | -0.48 | -0.39 | -0.31 | -0.30 | -0.30 | -0.35 | -0.38 | -0.36 | -0.35 | -0.34 | -0.33 | -0.33 | -0.34 | -0.38 | -0.40 | -0.4  | -0.47 | -0.50 |       |       |
|      | 2019 | -0.50 | -0.52 | -0.52 | -0.52 | -0.49 | -0.42 | -0.31 | -0.32 | -0.31 | -0.28 | -0.26 | -0.25 | -0.25 | -0.25 | -0.23 | -0.23 | -0.24 | -0.26 | -0.27 | -0.44 | -0.48 | -0.46 | -0.49 | -0.50 |       |
|      | 2020 | -0.50 | -0.46 | -0.43 | -0.35 | -0.39 | -0.51 | -0.58 | -0.38 | -0.39 | -0.40 | -0.35 | -0.40 | -0.38 | -0.34 | -0.31 | -0.29 | -0.32 | -0.38 | -0.36 | -0.43 | -0.53 | -0.64 | -0.75 | -0.75 |       |

Figure 18: Correlation between price and wind power for each hour and year (DK1 and DK2)

### 3.5 Holidays

Usage of the electricity decreases during weekends and public holidays and this has a significant effect on a prediction especially during Christmas or Easter. Due to that fact, each day was aligned with variable holiday with following value based of occurrence of day of week or public holiday:

- 1 - National Holidays (e.g. Easter Monday)[12]
- 1 - Sundays
- 0 - Not a public holidays (e.g. New Year's Eve)
- 0 - Other days

Each holiday is treated in weekday dummies as a Sunday.

## 4 Methodology

I decided to choose Danish market for forecasting and so on I want to apply methods and models most fitting to the characteristics of this market. I performed forecasting for 3 categories of values: wind power, consumption and price. In each category I made prognosis for few models which are described in Forecasting section. My forecasting framework for all of them is following:

1. Data preparation
2. Preliminary data analysis
3. Data forecasting (cycle for each model and day)
  - Optional deseasonalization
  - Data normalization
  - Day-ahead forecasting

#### 4. Verifying models' performance

All calculations were conducted with Python 3.7 language and its libraries, i.e. numpy, pandas, scipy. All the scripts and results made are accessible in public GIT repository <https://github.com/ajescode/energyForecast>.

Wind power prognosis and Consumption prognosis is provided only one day in advance so data forecasting is also performed day ahead. I used 3 calibration windows to compute predictions. They may take values of week multiples (7 days) because of the seasonal trend of energy production. Because chosen data has a limit of 1583 days, the maximum calibration window I considered is 728 days, around 2 years.

I consider few models for each category of forecasts (consumption, price and wind power) which I explain later in this section. General equation for each model (except of benchmark models for wind power and consumption) can be presented as:

$$\hat{Y}_{d,h} = \sum_{i=1}^n \beta_{d,h,i} X_{d,h}^i, \quad (1)$$

where  $Y_{d,h}$  is prediction and  $X_{d,h}^i$  is variable for given day ( $d$ ) and hour ( $h$ ). We can predict values for next whole day only, but basing on the variables from whole calibration window. Coefficients  $\beta_{h,i}$  have been approximated by ordinary least squares (OLS).

$$\vec{\beta} = (X^T X)^{-1} X^T Y, \quad (2)$$

where  $X$  is matrix of independent variables, and  $Y$  is vector of dependant variables of size of calibration window (multiple of 7 days).

Because prices of energy due to the wind dependence can have negative values I needed to normalize values. I used function *asinh* which was empirically confirmed to have best results for danish market among 4 different normalization functions.[1].

$$X_{d,h} = \text{asinh}(x_{d,h}) \equiv \log(x_{d,h} + \sqrt{x_{d,h}^2 + 1}), \quad (\text{asinh})$$

where  $Y_{d,h}$  is transformed value used for forecasts either as independent variable or dependent variable. Independent values in the model must be also transformed.  $y_{d,h}$  is normalized in a calibration window by:

$$x_{d,h} = \frac{1}{b_{d,h}}(x_{d,h}^* - a_{d,h}), \quad (\text{std})$$

where  $a$  is median and  $b$  is median absolute deviation (MAD) for given day and hour in the calibration window.  $y_{d,h}^*$  is original value of a parameter without any transformation yet. I used both simple normalization (std), and one with *asinh* function (asinh) for each category of forecasting.

Inverse function for transformation and normalization is following:

$$x_{d,h}^* = b_{d,h} \sinh(X_{d,h}) + a_{d,h}, \quad (3)$$

To eliminate seasonal component from the data I applied Hodrick-Prescott filter[15] before standard normalization with smoothing parameter derived from Ravn and Uhlig (2002) [11] and adjusted to the daily data as  $1600^4 * 6.25 = 110930628906.25$ . Similar method as the eliminating of seasonal component is also used in other works, i.e. Nowatorski, Weron 2016[8].

Types of transformations used (simple standard normalization is default without any name on the charts):

1. None: Standard normalization (std)
2. Asinh: Standard normalization (std) + asinh (asinh)
3. Asinh-hp: Standard normalization (std) + asinh (asinh) + HP filter
4. HP: Standard normalization (std) + HP filter

Despite of used transformations, the forecasts were performed with several different settings for each area (DK1 and DK2):

- Calibration window: 182, 364, 728
- Predicted dates: 2019.01.01-2019.12.31 (2019 year),  
2019.05.13-2020.05.12 (last year),  
2020.01.01-2020.05.12,  
2019.01.01-2020.05.12

## 4.1 Demand forecasting

First considering model is a benchmark model containing consumption forecast provided by Nordpool's database for day ahead ( $FL_{t,h}$ ). Its performance is analyzed in the section Demand data prognosis.

$$C_{d,h} = FC_{d,h} \quad (\text{C1})$$

Second model is extension of benchmark model (C1), where  $D_i, d$  is a vector of the values 0,1 for the corresponding day of a week. For day ( $d$ ) which is Monday  $D_{1,d} = 1$  and  $D_{2,d} = D_{3,d} = \dots = D_{7,d} = 0$ , for a day which is Tuesday  $D_{2,d} = 1$  and  $D_{1,d} = D_{3,d} = \dots = D_{7,d} = 0$  etc.

$$C_{d,h} = \sum_{i=1}^7 \beta_{0,i} D_{i,d} + \beta_1 FC_{d,h} + \varepsilon_{d,h} \quad (\text{C2})$$

Third model is extension of second model (C2), where are added 3 parameters according to a similar-day technique: consumption of previous day ( $C_{d-1,h}$ ), 2 days ago ( $C_{d-2,h}$ ) and week ago ( $C_{d-7,h}$ ).

$$C_{d,h} = \sum_{i=1}^7 \beta_{0,i} D_{i,d} + \beta_1 F C_{d,h} + \beta_2 C_{d-1,h} + \beta_3 C_{d-2,h} + \beta_4 C_{d-7,h} + \varepsilon_{d,h} \quad (\text{C3})$$

Fourth model is extension of third model (C3) where is also considered forecast of the wind power download from Nordpool's database, denoted as  $FW_{d,h}$ .

$$C_{d,h} = \sum_{i=1}^7 \beta_{0,i} D_{i,d} + \beta_1 F C_{d,h} + \beta_2 C_{d-1,h} + \beta_3 C_{d-2,h} + \beta_4 C_{d-7,h} + \beta_5 FW_{d,h} + \varepsilon_{d,h} \quad (\text{C4})$$

## 4.2 Wind power forecasting

First model is presented and analyzed in the section *Wind power data prognosis*. This is a benchmark model for further forecasts, where  $FW_{t,h} + \varepsilon_t$  is a day ahead forecast of wind power taken from Nordpool's data.

$$W_{t,h} = FW_{t,h} \quad (\text{W1})$$

Second model includes additionally day of week vector as the second demand model (C2).

$$W_{t,h} = \sum_{i=1}^7 \beta_{0,i} D_{i,d} + \beta FW_{t,h} + \varepsilon_{d,h} \quad (\text{W2})$$

Third model is extension of second model (W2) and contains also wind power from previous day ( $W_{t-1,h}$ ) and 2 days ago ( $W_{t-2,h}$ ) from the corresponding hour.

$$W_{t,h} = \sum_{i=1}^7 \beta_{0,i} D_{i,d} + \beta_1 FW_{t,h} + \beta_2 W_{t-1,h} + \beta_3 W_{t-2,h} + \varepsilon_{d,h} \quad (\text{W3})$$

Fourth model is extension of third one (W3) and contains additionally parameter of consumption forecast from previous day denoted as  $FL_{t,h}$ .

$$W_{t,h} = \sum_{i=1}^7 \beta_{0,i} D_{i,d} + \beta_1 FW_{t,h} + \beta_2 W_{t-1,h} + \beta_3 W_{t-2,h} + \beta_4 FC_{t,h} + \varepsilon_{d,h} \quad (\text{W4})$$

## 4.3 Price forecasting

First forecasting model of price consists of the same daf of week vector ( $D_{i,d}$ ) as the second demand model (C2).

$$P_{d,h} = \sum_{i=1}^7 \beta_{0,i} D_{i,d} + \varepsilon_{d,h} \quad (\text{P1})$$

Second model is an extension of first model (P1), where were added parameters of price for previous days: 1 day ago, 2 days ago and 1 week ago.

$$P_{d,h} = \sum_{i=1}^7 \beta_{0,i} D_{i,d} + \beta_1 p_{d-1,h} + \beta_2 p_{d-2,h} + \beta_3 p_{d-7,h} + \varepsilon_{d,h} \quad (\text{P2})$$

Third model is an extension of second model (P2) which consists additionally parameters of minimum ( $p_{d-1,min}$ ) and maximum value ( $p_{d-1,max}$ ) of previous day and value of price for last hour of previous day ( $p_{d-1,24}$ ).

$$P_{d,h} = \sum_{i=1}^7 \beta_{0,i} D_{i,d} + \beta_1 p_{d-1,h} + \beta_2 p_{d-2,h} + \beta_3 p_{d-7,h} + \beta_4 p_{d-1,min} + \beta_5 p_{d-1,max} + \beta_6 p_{d-1,24} + \varepsilon_{d,h} \quad (4)$$

Fourth model is an extension of third model (4) which is an expert model ARX2[4] with two exogenous variables: wind power prognosis ( $FW_{d,h}$ ) and consumption prognosis ( $FC_{d,h}$ ).

$$\begin{aligned} P_{d,h} = \sum_{i=1}^7 \beta_{0,i} D_{i,d} + \beta_1 p_{d-1,h} + \beta_2 p_{d-2,h} + \beta_3 p_{d-7,h} + \beta_4 p_{d-1,min} + \beta_5 p_{d-1,max} \\ + \beta_6 p_{d-1,24} + \beta_7 FW_{d,h} + \beta_8 FC_{d,h} + \varepsilon_{d,h} \end{aligned} \quad (\text{P4})$$

In the last fifth model, Nordpool's prognosis for wind and consumption are replaced with the best forecasts acquired from the wind and consumption prognosis. However only values in predicted period were replaced by better prognosis, not full rolling window, that's why eventually it wasn't very efficient.

Different models for different periods and areas were used. Summary of best models used were presented in next chapter.

$$\begin{aligned} P_{d,h} = \sum_{i=1}^7 \beta_{0,i} D_{i,d} + \beta_1 p_{d-1,h} + \beta_2 p_{d-2,h} + \beta_3 p_{d-7,h} + \beta_4 p_{d-1,min} + \beta_5 p_{d-1,max} \\ + \beta_6 p_{d-1,24} + \beta_7 FW_{d,h}^* + \beta_8 FC_{d,h}^* + \varepsilon_{d,h} \end{aligned} \quad (\text{P5})$$

## 5 Empirical results

For each forecast there is error analysis with Mean average error (MAE), Mean root square error (MRSE). All forecasts in the appropriate categories are compared to each other in order to get optimal result.

$$MAE = \frac{1}{24T} \sum_{d=1}^T \sum_{h=1}^{24} |\hat{\varepsilon}_{d,h}| \equiv \frac{1}{24T} \sum_{d=1}^T \sum_{h=1}^{24} |y_{d,h} - \hat{y}_{d,h}|, \quad (5)$$

$$RMSE = \sqrt{\frac{1}{24T} \sum_{d=1}^T \sum_{h=1}^{24} \hat{\varepsilon}_{d,h}^2} \equiv \sqrt{\frac{1}{24T} \sum_{d=1}^T \sum_{h=1}^{24} (y_{d,h} - \hat{y}_{d,h})^2}, \quad (6)$$

where  $T$  is size of calibration window.

From each consumption, wind and price prognosis were chosen the best results for each period and area and performed Diebold-Mariano test based on MAD criterion.

## 5.1 Demand forecasts

For both areas results with *asinh* were significantly worse than with standard normalization function. Especially for calibration window 182. The forecast with standard normalization was better for Models 2-4 than Nordpool's prognosis, however better accuracy was for longer calibration windows. Because drops of consumption level in 2020 results including this period were less accurate.

| Area | Dates                 | Window | C1      | C2      | C2<br>(asinh) | C2<br>(asinh-hp) | C2<br>(hp) | C3      | C3<br>(asinh) | C3<br>(asinh-hp) | C3<br>(hp) | C4      | C4<br>(asinh) | C4<br>(asinh-hp) | C4<br>(hp) |
|------|-----------------------|--------|---------|---------|---------------|------------------|------------|---------|---------------|------------------|------------|---------|---------------|------------------|------------|
|      |                       | 182    | 22.7044 | 21.0269 | 21.2785       | 24.1466          | 23.8343    | 21.3643 | 21.6734       | 24.3640          | 24.0067    | 21.4608 | 21.8100       | 24.5258          | 24.1166    |
|      | 2019.01.01-2019.12.31 | 364    | 22.7044 | 20.5738 | 20.6452       | 36.0889          | 36.0494    | 20.6044 | 20.7099       | 36.2072          | 36.1524    | 20.6357 | 20.7542       | 36.2376          | 36.1422    |
|      |                       | 728    | 22.7044 | 20.4818 | 20.5553       | 59.5941          | 59.5155    | 20.4128 | 20.5007       | 59.3679          | 59.5639    | 20.3765 | 20.4789       | 59.4302          | 59.6149    |
|      |                       | 182    | 23.7079 | 21.9972 | 22.3086       | 24.7041          | 24.3825    | 23.3403 | 22.6712       | 24.9615          | 24.5930    | 22.4058 | 22.7671       | 25.0662          | 24.6507    |
|      | 2019.01.01-2020.05.12 | 364    | 23.7079 | 21.6325 | 21.6570       | 35.8995          | 35.7843    | 21.7035 | 21.7714       | 35.8886          | 35.8010    | 21.6997 | 21.7899       | 35.8401          | 35.7073    |
|      |                       | 728    | 23.7079 | 21.5292 | 21.5643       | 60.5532          | 60.5344    | 21.4925 | 21.5529       | 60.4016          | 60.4206    | 21.4406 | 21.5306       | 60.1393          | 60.0978    |
| DK1  |                       | 182    | 24.5221 | 22.8302 | 23.0908       | 25.4669          | 25.1809    | 23.6119 | 23.4355       | 25.6814          | 25.3691    | 23.2260 | 23.5189       | 25.7723          | 25.4160    |
|      | 2019.05.13-2020.05.12 | 364    | 24.5221 | 22.4451 | 22.4610       | 36.5130          | 36.3555    | 22.5117 | 22.5626       | 36.5040          | 36.3466    | 22.4685 | 22.5485       | 36.5255          | 36.3288    |
|      |                       | 728    | 24.5221 | 22.3265 | 22.3395       | 61.6104          | 61.6029    | 22.9986 | 22.3290       | 61.4345          | 61.4787    | 22.2225 | 22.2967       | 61.0137          | 60.9890    |
|      |                       | 182    | 26.4619 | 26.6599 | 25.1339       | 26.2342          | 25.8871    | 25.0187 | 25.4097       | 26.6014          | 26.2021    | 24.9993 | 25.3940       | 26.5495          | 26.1163    |
|      | 2020.01.01-2020.05.12 | 364    | 26.4619 | 24.5378 | 24.4340       | 35.7996          | 35.5566    | 24.7197 | 24.6847       | 35.0143          | 34.8365    | 24.6198 | 24.6324       | 34.7494          | 34.5140    |
|      |                       | 728    | 26.4619 | 24.4039 | 24.3334       | 63.1851          | 62.6947    | 24.4557 | 24.4404       | 63.2386          | 62.7718    | 24.3607 | 24.4166       | 62.0852          | 61.4231    |

Figure 19: MAE on the consumption forecasts (DK1)

| Area | Dates                 | Window | C1      | C2      | C2<br>(asinh) | C2<br>(asinh-hp) | C2<br>(hp) | C3      | C3<br>(asinh) | C3<br>(asinh-hp) | C3<br>(hp) | C4      | C4<br>(asinh) | C4<br>(asinh-hp) | C4<br>(hp) |
|------|-----------------------|--------|---------|---------|---------------|------------------|------------|---------|---------------|------------------|------------|---------|---------------|------------------|------------|
|      |                       | 182    | 19.4739 | 18.5070 | 19.1465       | 19.0951          | 18.4566    | 18.6114 | 19.0274       | 18.9975          | 18.1329    | 18.2866 | 19.2230       | 19.2031          | 18.2637    |
|      | 2019.01.01-2019.12.31 | 364    | 19.4739 | 17.8111 | 17.7460       | 17.7535          | 17.7854    | 17.6134 | 17.9143       | 17.9818          | 17.6679    | 17.7855 | 18.1222       | 18.2021          | 17.8651    |
|      |                       | 728    | 19.4739 | 17.6512 | 17.6094       | 18.0666          | 18.0412    | 17.3886 | 17.5390       | 18.0941          | 17.8905    | 17.5472 | 17.7300       | 18.2579          | 18.0342    |
|      |                       | 182    | 19.8874 | 18.5865 | 19.2647       | 19.2070          | 18.5321    | 18.2830 | 19.1055       | 19.0654          | 18.2456    | 18.3780 | 19.2632       | 18.2462          |            |
|      | 2019.01.01-2020.05.12 | 364    | 19.8874 | 18.2011 | 18.1744       | 18.1461          | 18.1316    | 18.0487 | 18.3232       | 18.3318          | 18.0357    | 18.1626 | 18.4691       | 18.4902          | 18.1706    |
|      |                       | 728    | 19.8874 | 18.2647 | 18.2180       | 18.5074          | 18.4816    | 18.6022 | 18.1930       | 18.5798          | 18.3977    | 18.1841 | 18.3504       | 18.7252          | 18.5168    |
| DK2  |                       | 182    | 18.9997 | 17.5838 | 18.2321       | 18.1748          | 17.5352    | 17.1995 | 17.8265       | 17.7952          | 17.1671    | 17.2685 | 17.9523       | 17.9228          | 17.2436    |
|      | 2019.05.13-2020.05.12 | 364    | 18.9997 | 17.4321 | 17.4237       | 17.3046          | 17.2799    | 17.2091 | 17.3354       | 17.3093          | 17.1650    | 17.2150 | 17.3602       | 17.3477          | 17.1868    |
|      |                       | 728    | 18.9997 | 17.4156 | 17.3765       | 17.5042          | 17.4841    | 17.2369 | 17.3201       | 17.6461          | 17.5203    | 17.3067 | 17.4280       | 17.7438          | 17.5863    |
|      |                       | 182    | 21.0221 | 18.8044 | 19.5993       | 19.5139          | 18.7391    | 18.6167 | 19.3198       | 19.2518          | 18.5548    | 18.6288 | 19.3735       | 19.2918          | 18.5725    |
|      | 2020.01.01-2020.05.12 | 364    | 21.0221 | 19.2717 | 19.3505       | 19.2236          | 19.0818    | 19.2435 | 19.4456       | 19.2923          | 19.0451    | 19.1973 | 19.4211       | 19.2809          | 19.0090    |
|      |                       | 728    | 21.0221 | 19.9481 | 19.8869       | 19.7163          | 19.6904    | 19.9111 | 19.9880       | 19.9126          | 19.7895    | 19.9320 | 20.0529       | 20.0076          | 19.8412    |

Figure 20: MAE on the consumption forecasts (DK2)

| Area                  | Dates | Window  | C1      | C2<br>(asinh) | C2<br>(asinh-hp) | C2<br>(hp) | C3      | C3<br>(asinh) | C3<br>(asinh-hp) | C3<br>(hp) | C4<br>(asinh) | C4<br>(asinh-hp) | C4<br>(hp) |         |
|-----------------------|-------|---------|---------|---------------|------------------|------------|---------|---------------|------------------|------------|---------------|------------------|------------|---------|
|                       |       |         | 182     | 36.9021       | 35.1851          | 35.3440    | 37.6028 | 37.3393       | 35.4515          | 35.6229    | 37.7305       | 37.4808          | 35.4539    | 35.6312 |
| 2019.01.01-2019.12.31 | 364   | 36.9021 | 34.8179 | 34.8509       | 47.3679          | 47.2368    | 34.7848 | 34.8236       | 47.4697          | 47.3370    | 34.7550       | 34.8095          | 47.5017    | 47.3267 |
|                       | 728   | 36.9021 | 34.7436 | 34.7824       | 68.0356          | 68.1554    | 34.6753 | 34.7107       | 67.8902          | 67.9854    | 34.6132       | 34.6703          | 67.9224    | 68.0114 |
|                       | 182   | 36.7802 | 34.9363 | 35.1362       | 37.0798          | 36.8179    | 35.2543 | 35.4395       | 37.3173          | 37.0468    | 35.2632       | 35.4683          | 37.3735    | 37.0368 |
|                       | 364   | 36.7802 | 34.6373 | 34.6133       | 46.5772          | 46.4119    | 34.6808 | 34.6729       | 46.5696          | 46.4417    | 34.6375       | 34.6675          | 46.5427    | 46.3598 |
| DK1                   | 728   | 36.7802 | 34.5603 | 34.5601       | 68.6243          | 68.5919    | 34.5378 | 34.5361       | 68.5395          | 68.4949    | 34.4697       | 34.5156          | 68.3048    | 68.2087 |
|                       | 182   | 39.3265 | 37.4799 | 37.5582       | 39.3605          | 39.2253    | 37.7994 | 37.8761       | 39.5733          | 39.4245    | 37.7968       | 37.8899          | 39.6054    | 39.3842 |
|                       | 364   | 39.3265 | 37.2244 | 37.1853       | 48.5201          | 48.3321    | 37.2624 | 37.2402       | 48.5115          | 48.3304    | 37.1906       | 37.2170          | 48.5104    | 48.2850 |
|                       | 728   | 39.3265 | 37.1387 | 37.1166       | 70.1598          | 70.5985    | 37.1220 | 37.0906       | 70.4420          | 70.3902    | 37.0382       | 37.0709          | 70.0604    | 69.9530 |
| 2019.05.13-2020.05.12 | 182   | 36.4434 | 34.2443 | 34.5594       | 35.6050          | 35.3475    | 34.7072 | 34.9315       | 36.1592          | 35.8289    | 34.7344       | 35.0176          | 36.2513    | 35.7201 |
|                       | 364   | 36.4434 | 34.1367 | 33.9527       | 44.3350          | 44.0687    | 34.9340 | 34.2557       | 44.0049          | 43.8910    | 34.3130       | 34.2750          | 43.8031    | 43.5964 |
|                       | 728   | 36.4434 | 34.0522 | 33.9424       | 70.2144          | 69.7799    | 34.1577 | 34.0524       | 70.2905          | 69.8741    | 34.0730       | 34.0876          | 69.3434    | 68.7471 |

Figure 21: RMSE on the consumption forecasts (DK1)

| Area                  | Dates | Window  | C1      | C2<br>(asinh) | C2<br>(asinh-hp) | C2<br>(hp) | C3      | C3<br>(asinh) | C3<br>(asinh-hp) | C3<br>(hp) | C4<br>(asinh) | C4<br>(asinh-hp) | C4<br>(hp) |         |
|-----------------------|-------|---------|---------|---------------|------------------|------------|---------|---------------|------------------|------------|---------------|------------------|------------|---------|
|                       |       |         | 182     | 28.3419       | 26.0223          | 25.9419    | 26.1028 | 26.1619       | 25.2956          | 25.6072    | 25.7888       | 25.4555          | 25.5330    | 25.8912 |
| 2019.01.01-2019.12.31 | 364   | 28.3419 | 25.9872 | 25.9431       | 26.5737          | 26.5666    | 25.1838 | 25.3110       | 25.9992          | 25.8112    | 25.3099       | 25.4714          | 26.1508    | 25.9294 |
|                       | 728   | 28.3419 | 25.9872 | 25.9431       | 28.1959          | 28.1903    | 27.5225 | 26.8667       | 27.8857          | 27.8809    | 26.8643       | 27.0062          | 28.1566    | 28.1553 |
|                       | 182   | 29.4301 | 27.5234 | 28.1959       | 28.1903          | 27.5225    | 26.8667 | 27.8857       | 27.8809          | 26.8643    | 27.0062       | 28.1566          | 27.0045    |         |
|                       | 364   | 29.4301 | 27.1708 | 27.1300       | 27.2238          | 27.2374    | 26.4286 | 26.4513       | 26.9463          | 26.8598    | 26.5347       | 26.8127          | 26.9255    | 26.6226 |
| DK2                   | 728   | 29.4301 | 27.3285 | 27.2664       | 27.6885          | 27.6941    | 26.4286 | 26.4513       | 26.9463          | 26.8598    | 26.5347       | 26.8127          | 27.0935    | 26.9706 |
|                       | 182   | 28.0782 | 26.0545 | 26.7303       | 26.7120          | 26.0410    | 25.9664 | 26.1364       | 26.1275          | 25.3848    | 25.4814       | 26.2855          | 26.2807    | 25.4729 |
|                       | 364   | 28.0782 | 25.9346 | 25.9279       | 25.9514          | 25.9351    | 25.2422 | 25.2880       | 25.3993          | 25.2849    | 25.2366       | 25.3395          | 25.4121    | 25.2846 |
|                       | 728   | 28.0782 | 25.9816 | 25.9396       | 26.2186          | 26.2190    | 25.2271 | 25.1870       | 25.6051          | 25.5894    | 25.2853       | 25.2830          | 25.6968    | 25.6474 |
| 2019.05.13-2020.05.12 | 182   | 32.2284 | 29.6137 | 30.3570       | 30.3026          | 29.5657    | 29.9411 | 29.5000       | 29.5201          | 28.8928    | 28.9598       | 29.6497          | 29.6070    | 28.9111 |
|                       | 364   | 32.2284 | 30.0975 | 30.1510       | 30.0880          | 29.9914    | 29.2027 | 29.2406       | 29.1888          | 29.1018    | 29.1200       | 29.1925          | 29.1427    | 29.0221 |
|                       | 728   | 32.2284 | 30.7099 | 30.6054       | 30.5397          | 30.5754    | 29.5767 | 29.3541       | 29.3892          | 29.5469    | 29.6370       | 29.4624          | 29.5265    | 29.6409 |
|                       | 182   | 32.2284 | 30.0975 | 30.1510       | 30.0880          | 29.9914    | 29.2027 | 29.2406       | 29.1888          | 29.1018    | 29.1200       | 29.1925          | 29.1427    | 29.0221 |
| 2020.01.01-2020.05.12 | 364   | 32.2284 | 30.7099 | 30.6054       | 30.5397          | 30.5754    | 29.5767 | 29.3541       | 29.3892          | 29.5469    | 29.6370       | 29.4624          | 29.5265    | 29.6409 |
|                       | 728   | 32.2284 | 30.7099 | 30.6054       | 30.5397          | 30.5754    | 29.5767 | 29.3541       | 29.3892          | 29.5469    | 29.6370       | 29.4624          | 29.5265    | 29.6409 |

Figure 22: RMSE on the consumption forecasts (DK2)

For area DK1 the best performing model is Model C4 with 728 length window, but with slightly worse performance compared to Model C2 (728 w, asinh) for period 2020.01.01-2020.05.12.

| Area | Dates                 | Model 1      | C1<br>728 | C2<br>182 | C2<br>asinh | C2<br>364 | C2<br>asinh | C2<br>728 | C2<br>182 | C2<br>asinh | C3<br>364 | C3<br>asinh | C3<br>728 | C3<br>182 | C3<br>asinh | C4<br>182 | C4<br>364 | C4<br>asinh | C4<br>728 | C4<br>asinh |        |       |
|------|-----------------------|--------------|-----------|-----------|-------------|-----------|-------------|-----------|-----------|-------------|-----------|-------------|-----------|-----------|-------------|-----------|-----------|-------------|-----------|-------------|--------|-------|
| DK1  | 2020.01.01-2020.05.12 | C1.728       | 0.000     | 6.263     | 4.549       | 8.080     | 8.317       | 9.848     | 9.695     | 4.805       | 3.425     | 6.994       | 6.964     | 9.300     | 9.021       | 4.644     | 3.340     | 7.109       | 6.928     | 9.557       | 8.969  |       |
|      |                       | C2.182       | -6.263    | 0.000     | -4.618      | 0.883     | 1.444       | 1.493     | 1.778     | -3.500      | -5.233    | -0.378      | -0.143    | 1.142     | 1.166       | -2.444    | -4.410    | 0.240       | 0.153     | 1.659       | 1.271  |       |
|      |                       | C2.182.asinh | -4.549    | 4.618     | 0.000       | 3.759     | 4.271       | 3.949     | 4.210     | 0.76        | -2.136    | 2.293       | 2.411     | 3.454     | 3.485       | 1.634     | 2.710     | 2.585       | 3.892     | 3.506       |        |       |
|      |                       | C2.364       | -8.083    | -3.759    | 0.000       | 1.682     | 1.935       | 2.236     | -2.781    | -4.492      | -1.949    | -1.283      | 0.812     | 0.837     | -2.307      | -3.965    | -0.684    | -0.701      | 1.598     | 0.961       |        |       |
|      |                       | C2.364.asinh | -8.317    | -1.444    | -4.271      | -1.682    | 0.000       | 0.347     | 1.329     | -3.111      | -4.840    | -2.497      | -2.353    | -0.187    | -0.057      | -2.650    | -4.283    | -1.352      | -1.502    | 0.584       | 0.140  |       |
|      |                       | C2.728       | 9.848     | -1.493    | -3.949      | -1.935    | -0.347      | 0.000     | 1.216     | -3.085      | -4.668    | -2.741      | -2.169    | -0.684    | -0.386      | -2.666    | -4.204    | -1.541      | -1.522    | 0.467       | -0.116 |       |
|      |                       | C2.728.asinh | 9.695     | -1.778    | -4.210      | -2.236    | -1.329      | -1.216    | 0.000     | 3.259       | -4.835    | -2.899      | -2.693    | -1.230    | -1.198      | -2.858    | -4.366    | -1.841      | -1.971    | -0.241      | 0.786  |       |
|      |                       | C3.182       | -4.805    | 3.500     | -0.780      | 2.781     | 3.111       | 3.085     | 3.259     | 0.000       | -3.820    | 1.967       | 1.977     | 3.078     | 3.009       | 0.191     | 2.739     | 2.440       | 2.171     | 3.547       | 3.068  |       |
|      |                       | C3.182.asinh | -3.425    | 5.233     | 2.136       | 4.492     | 4.840       | 4.668     | 4.835     | 3.820       | 0.000     | 3.992       | 4.134     | 4.134     | 4.798       | 2.891     | 0.163     | 4.312       | 4.223     | 5.168       | 4.818  |       |
|      |                       | C3.364       | -6.994    | 0.378     | -2.293      | 1.949     | 2.497       | 2.741     | 2.899     | -1.967      | -3.992    | 0.000       | 5.058     | 5.163     | 2.706       | -1.523    | -3.409    | 1.392       | 0.870     | 2.767       | 2.669  |       |
|      |                       | C3.364.asinh | -6.964    | 0.143     | -2.411      | 1.283     | 2.351       | 2.169     | 2.693     | -1.977      | -4.134    | -0.508      | 0.000     | 2.223     | 2.681       | -1.597    | -3.542    | 0.634       | 0.720     | 2.911       | 2.647  |       |
|      |                       | C3.728       | 9.300     | -1.142    | -3.452      | -0.812    | 0.187       | 0.684     | 1.230     | -3.076      | -4.761    | -3.163      | -2.223    | 0.000     | 0.256       | -2.589    | -4.227    | -1.415      | -1.376    | 1.826       | 0.494  |       |
|      |                       | C3.728.asinh | 9.021     | -1.166    | -3.455      | -0.837    | 0.057       | 0.886     | 1.198     | -3.009      | -4.798    | -2.706      | -2.681    | -0.256    | 0.000       | -2.572    | -4.267    | -1.379      | -1.629    | 1.017       | 0.470  |       |
|      |                       | C4.182       | -6.444    | 2.444     | -0.773      | 2.307     | 2.650       | 2.666     | 2.858     | -0.191      | -2.891    | 1.523       | 1.597     | 2.589     | 2.572       | 0.000     | -3.668    | 2.413       | 2.079     | 3.259       | 2.783  |       |
|      |                       | C4.182.asinh | -3.340    | 4.410     | 1.634       | 3.965     | 4.283       | 4.204     | 4.366     | 2.739       | -0.163    | 3.409       | 3.542     | 4.227     | 4.267       | 3.668     | 0.000     | 4.315       | 4.183     | 4.915       | 4.552  |       |
|      |                       | C4.364       | -7.109    | -0.240    | -2.710      | 0.684     | 1.352       | 1.541     | 1.841     | -2.440      | -4.312    | -1.932      | -1.934    | -0.634    | 1.415       | 1.379     | -2.413    | -4.315      | 0.000     | -0.170      | 2.763  | 1.733 |
|      |                       | C4.364.asinh | -6.928    | -0.153    | -2.585      | 0.701     | 1.520       | 1.522     | 1.971     | -2.171      | -4.223    | -0.870      | -0.720    | 1.376     | 1.629       | -2.079    | -4.183    | 0.170       | 0.000     | 2.472       | 2.152  |       |
|      |                       | C4.728       | 9.557     | -1.659    | -3.892      | -1.598    | -0.584      | 0.467     | 0.241     | -3.547      | -5.168    | -3.787      | -2.911    | -1.826    | -1.017      | -3.259    | -4.915    | -2.763      | -2.472    | 0.000       | 0.874  |       |
|      |                       | C4.728.asinh | 8.969     | -1.271    | -3.506      | -0.961    | -0.140      | 0.116     | 0.786     | -3.068      | -4.818    | -2.669      | -2.647    | -0.494    | -0.470      | -2.793    | -4.552    | -1.733      | -2.152    | 0.874       | 0.000  |       |

Figure 23: Diebold-Mariano Test for consumption forecasts (DK1)

There are different settings for area DK2, but for every period the best model is Model Model C3.

- 2019.01.01-2019.12.31: Model C3, 728 window, None
- 2019.05.13-2020.05.12: Model C3, 364 window, HP
- 2019.01.01-2020.05.12: Model C3, 364 window, HP
- 2020.01.01-2020.05.12: Model C3, 182 window, HP

| Area | Dates                 | Model 1      | C2<br>182 | C2<br>364 | C2<br>728 | C2<br>182 | C2<br>asinh | C2<br>hp | C3<br>182 | C3<br>364 | C3<br>728 | C3<br>182 | C3<br>asinh | C3<br>hp | C3<br>728 | C3<br>182 | C3<br>asinh | C4<br>182 | C4<br>364 | C4<br>728 | C4<br>182 | C4<br>asinh | C4<br>hp | C4<br>728 | C4<br>asinh |  |
|------|-----------------------|--------------|-----------|-----------|-----------|-----------|-------------|----------|-----------|-----------|-----------|-----------|-------------|----------|-----------|-----------|-------------|-----------|-----------|-----------|-----------|-------------|----------|-----------|-------------|--|
| DK2  | 2020.01.01-2020.05.12 | C2.182       | 0.000     | -3.683    | -8.047    | 1.755     | -3.697      | 2.299    | -2.740    | -3.795    | -1.515    | -6.175    | -6.385      | -5.377   | 1.574     | 2.052     | -2.435      | -3.637    | -1.278    | -6.187    | -6.600    | -5.576      |          |           |             |  |
|      |                       | C2.364       | 3.683     | 0.000     | -10.983   | 3.988     | -0.255      | 2.489    | 0.226     | 1.735     | -2.493    | -4.683    | -3.179      | 3.858    | 4.130     | 0.588     | -1.101      | 1.996     | -4.375    | -4.974    | -3.460    |             |          |           |             |  |
|      |                       | C2.728       | 8.047     | 10.983    | 0.000     | 7.510     | 3.126       | 7.717    | 1.481     | 3.316     | 6.090     | 0.252     | -0.258      | 0.952    | 7.372     | 7.555     | 5.248       | 3.454     | 6.277     | 0.108     | -0.660    | 0.633       |          |           |             |  |
|      |                       | C3.182       | -1.755    | -3.988    | -7.515    | 0.000     | 8.429       | 1.323    | 4.389     | 5.432     | -2.989    | -7.925    | -8.060      | -8.636   | -0.384    | 1.158     | -0.427      | -5.254    | -2.712    | -7.919    | -8.260    | -7.030      |          |           |             |  |
|      |                       | C3.182.asinh | 3.697     | 0.255     | -3.126    | 8.429     | 0.000       | 9.040    | 0.453     | -0.724    | 1.639     | 3.195     | -3.543      | -2.467   | 7.776     | 8.313     | 0.724       | -0.583    | 1.845     | -3.265    | 3.813     | -2.703      |          |           |             |  |
|      |                       | C3.182.hp    | -2.299    | -4.289    | -7.717    | -1.315    | 0.000       | 4.696    | 5.725     | -3.421    | -8.122    | -8.281    | -7.334      | -1.936   | -0.540    | -4.345    | -5.554      | -3.144    | -8.121    | -8.479    | -7.524    |             |          |           |             |  |
|      |                       | C3.364       | 2.740     | -0.228    | -4.981    | 4.389     | -0.453      | 4.690    | 0.000     | -4.310    | 4.260     | -6.698    | -8.766      | -4.871   | 4.223     | 4.499     | 1.590       | 3.315     | 4.323     | 4.604     | -9.025    | 5.238       |          |           |             |  |
|      |                       | C3.364.asinh | 3.795     | 1.300     | -3.310    | 5.423     | 0.724       | 5.723    | 4.310     | 0.000     | 6.638     | 5.130     | -6.843      | -5.130   | -6.843    | 2.876     | 5.290       | 5.523     | 4.480     | 0.869     | 0.556     | -5.182      | -7.132   | -3.352    |             |  |
|      |                       | C3.728       | 6.175     | 4.293     | -0.252    | 7.925     | 3.195       | 8.122    | 8.668     | 5.130     | 9.342     | 0.000     | -1.573      | 1.300    | 7.757     | 7.935     | 8.801       | 5.233     | 9.428     | -0.613    | -2.324    | 0.712       |          |           |             |  |
|      |                       | C3.728.asinh | 6.385     | 4.663     | 0.258     | 8.060     | 3.543       | 8.281    | 8.766     | 5.183     | 9.839     | 1.573     | 0.000       | 2.032    | 7.883     | 8.083     | 8.836       | 6.795     | 9.866     | 0.960     | -1.780    | 1.438       |          |           |             |  |
|      |                       | C3.728.hp    | 5.377     | 3.179     | -0.955    | 6.885     | 2.467       | 7.334    | 4.871     | 2.971     | 8.861     | -1.300    | -2.032      | 0.000    | 6.715     | 7.172     | 5.190       | 3.139     | 8.789     | -1.451    | -2.543    | -1.541      |          |           |             |  |
|      |                       | C4.182       | -1.574    | -3.858    | -7.378    | 0.384     | -7.776      | 1.939    | -4.223    | -5.260    | -2.811    | -7.783    | -6.715      | 0.000    | 2.854     | -3.971    | -5.196      | -2.847    | -7.845    | -8.176    | -6.966    |             |          |           |             |  |
|      |                       | C4.182.hp    | -2.052    | -4.130    | -7.555    | -1.159    | 8.313       | 0.540    | -4.499    | 5.523     | -3.245    | -7.895    | -8.083      | -7.172   | -2.854    | 0.000     | -4.256      | -5.465    | -3.043    | -8.019    | -8.388    | -7.425      |          |           |             |  |
|      |                       | C4.364       | 2.435     | -0.586    | -5.245    | 4.027     | -0.724      | 4.345    | -1.590    | -4.468    | 2.815     | 8.801     | -8.836      | -5.190   | 3.971     | 4.256     | 0.000       | -4.686    | 4.049     | 4.892     | -9.262    | -5.591      |          |           |             |  |
|      |                       | C4.364.asinh | 3.637     | 1.101     | 0.354     | 5.254     | 0.583       | 5.554    | 3.315     | 0.869     | 5.748     | 5.233     | -6.795      | -3.139   | 5.196     | 5.465     | 4.686       | 0.000     | 6.784     | -5.447    | -7.350    | -3.562      |          |           |             |  |
|      |                       | C4.364.hp    | 1.278     | -1.996    | -0.277    | 2.712     | -1.945      | 3.144    | -4.323    | -6.556    | -1.262    | 9.426     | -9.866      | -8.789   | 2.647     | 3.043     | -4.049      | -6.784    | 0.000     | 9.617     | -10.255   | -9.270      |          |           |             |  |
|      |                       | C4.728       | 6.187     | 4.375     | -0.108    | 7.919     | 3.265       | 8.121    | 8.604     | 5.182     | 9.368     | 0.613     | -0.960      | 1.451    | 7.845     | 8.019     | 8.992       | 5.447     | 9.617     | 0.000     | -2.419    | 0.976       |          |           |             |  |
|      |                       | C4.728.asinh | 6.000     | 4.974     | 0.660     | 8.260     | 3.813       | 8.479    | 8.025     | 7.132     | 10.111    | 2.324     | 1.780       | 2.543    | 8.176     | 8.368     | 9.262       | 7.350     | 10.255    | 2.419     | 0.000     | 2.152       |          |           |             |  |
|      |                       | C4.728.hp    | 5.576     | 3.460     | -0.633    | 7.030     | 2.703       | 7.524    | 5.238     | 3.352     | 8.987     | -0.712    | -1.438      | 1.541    | 6.966     | 7.425     | 5.591       | 3.562     | 9.270     | -0.976    | -2.152    | 0.874       |          |           |             |  |

Figure 24: Diebold-Mariano Test for consumption forecasts (DK2)

## 5.2 Wind power forecasts

The retrieved results from wind power forecasting with standard normalization were significantly better for DK1, and very slightly better for DK2 comparing to the Nord-pool's forecast. Asinh function as normalization was useful only for part of cases with

short calibration window, so I don't consider it as successful results. MAE for Model 4 with 728 window length and for full 2019 year is 6,6% lower, while MAE for last period (2020.01.01-2020.05.12) is 22,19% lower.

| Area                  | Dates | Window | W1  | W2<br>(asinh) | W2<br>(asinh-hp) | W2<br>(hp) | W3       | W3<br>(asinh) | W3<br>(asinh-hp) | W3<br>(hp) | W4       | W4<br>(asinh) | W4<br>(asinh-hp) | W4<br>(hp) |          |          |
|-----------------------|-------|--------|-----|---------------|------------------|------------|----------|---------------|------------------|------------|----------|---------------|------------------|------------|----------|----------|
|                       |       |        | 182 | 234.5053      | 217.4789         | 215.8943   | 214.7341 | 215.6551      | 219.6931         | 218.7317   | 217.7375 | 218.1050      | 220.0010         | 220.0222   | 218.0514 | 217.8571 |
| 2019.01.01-2019.12.31 |       |        | 364 | 234.5053      | 217.1779         | 214.9680   | 210.8029 | 211.5926      | 218.82126        | 216.0995   | 212.2605 | 213.0257      | 218.5291         | 216.3776   | 213.2433 | 213.6965 |
|                       |       |        | 728 | 234.5053      | 218.8722         | 217.1265   | 225.2318 | 224.0590      | 219.0693         | 217.3630   | 226.1964 | 224.8970      | 219.0649         | 217.3302   | 227.0352 | 225.1335 |
| 2019.01.01-2020.05.12 |       |        | 182 | 283.8955      | 235.7740         | 233.8541   | 232.4461 | 233.3719      | 237.8470         | 237.0606   | 235.8624 | 236.1541      | 238.3007         | 238.3563   | 237.1771 | 236.9041 |
|                       |       |        | 364 | 283.8955      | 239.1466         | 236.6201   | 231.8007 | 232.9267      | 240.6124         | 238.2046   | 233.6711 | 234.7300      | 240.5791         | 238.0895   | 234.5342 | 235.1725 |
| DK1                   |       |        | 728 | 283.8955      | 248.2129         | 245.1569   | 246.4548 | 246.1251      | 248.4362         | 245.3776   | 247.5864 | 247.0758      | 247.8012         | 248.5268   | 248.1401 | 247.2035 |
| 2019.05.13-2020.05.12 |       |        | 182 | 304.0500      | 236.6935         | 235.3443   | 232.4261 | 233.2747      | 239.2110         | 238.6459   | 236.1465 | 236.2941      | 240.2263         | 240.6466   | 238.4192 | 237.8396 |
|                       |       |        | 364 | 304.0500      | 243.1853         | 240.4881   | 231.3513 | 232.7017      | 244.5851         | 242.0384   | 233.3375 | 234.4189      | 244.5565         | 241.9797   | 234.4015 | 235.0000 |
|                       |       |        | 728 | 304.0500      | 256.0665         | 252.4397   | 242.4979 | 242.1728      | 256.1935         | 252.5289   | 243.4029 | 242.7863      | 255.4059         | 251.4758   | 244.1583 | 242.9778 |
| 2020.01.01-2020.05.12 |       |        | 182 | 410.4398      | 284.1102         | 283.1422   | 281.0570 | 281.9934      | 287.6680         | 287.3618   | 285.6044 | 285.6874      | 288.5216         | 288.6716   | 289.6550 | 289.1759 |
|                       |       |        | 364 | 410.4398      | 290.4366         | 290.0415   | 289.4264 | 291.5025      | 302.0856         | 298.8966   | 292.4296 | 294.2944      | 301.0921         | 297.6750   | 292.9641 | 294.1102 |
|                       |       |        | 728 | 410.4398      | 328.7344         | 322.0822   | 304.6984 | 306.6825      | 329.0299         | 322.2599   | 306.2883 | 307.9427      | 326.6640         | 319.1640   | 306.0596 | 307.7717 |

Figure 25: MAE on the wind power forecasts (DK1)

| Area                  | Dates | Window | W1  | W2<br>(asinh) | W2<br>(asinh-hp) | W2<br>(hp) | W3      | W3<br>(asinh) | W3<br>(asinh-hp) | W3<br>(hp) | W4      | W4<br>(asinh) | W4<br>(asinh-hp) | W4<br>(hp) |         |         |
|-----------------------|-------|--------|-----|---------------|------------------|------------|---------|---------------|------------------|------------|---------|---------------|------------------|------------|---------|---------|
|                       |       |        | 182 | 64.5167       | 66.3122          | 67.0413    | 67.4307 | 66.6758       | 66.8695          | 67.7520    | 68.1468 | 67.1943       | 67.0683          | 67.9557    | 68.2130 | 67.2834 |
| 2019.01.01-2019.12.31 |       |        | 364 | 64.5167       | 65.0329          | 65.4815    | 67.8653 | 67.2296       | 65.2724          | 65.8123    | 68.1706 | 67.3852       | 65.1757          | 65.8565    | 68.5175 | 67.5938 |
|                       |       |        | 728 | 64.5167       | 65.4080          | 66.0257    | 74.7557 | 73.8559       | 65.5347          | 65.2718    | 75.0148 | 74.0370       | 65.5368          | 66.2576    | 74.7739 | 73.8716 |
| 2019.01.01-2020.05.12 |       |        | 182 | 67.2619       | 69.0686          | 69.6017    | 69.8011 | 69.2103       | 69.8881          | 70.5497    | 70.7663 | 70.0300       | 70.0938          | 70.6660    | 70.8996 | 70.2510 |
|                       |       |        | 364 | 67.2619       | 67.5893          | 67.9303    | 69.8319 | 69.2777       | 68.0340          | 68.4954    | 70.3540 | 69.6380       | 68.0403          | 68.5525    | 70.6170 | 69.8619 |
| DK2                   |       |        | 728 | 67.2619       | 67.4937          | 67.8985    | 76.1776 | 75.3422       | 67.1115          | 68.2473    | 76.3622 | 75.4676       | 67.7688          | 68.2556    | 76.2949 | 75.4954 |
| 2019.05.13-2020.05.12 |       |        | 182 | 66.8141       | 69.9545          | 70.5639    | 70.9389 | 70.2817       | 70.7369          | 71.4112    | 71.7878 | 71.0638       | 70.7960          | 71.3476    | 71.7381 | 71.0793 |
|                       |       |        | 364 | 66.8141       | 68.1591          | 68.4344    | 70.8680 | 70.2773       | 68.5159          | 68.8413    | 71.0388 | 70.5430       | 68.5785          | 68.8640    | 71.1720 | 70.7202 |
|                       |       |        | 728 | 66.8141       | 67.8917          | 68.0205    | 77.0133 | 76.4850       | 68.0327          | 68.2143    | 77.0524 | 76.4654       | 68.0471          | 68.2089    | 77.3476 | 76.7213 |
| 2020.01.01-2020.05.12 |       |        | 182 | 74.7957       | 76.6333          | 76.6285    | 76.3066 | 76.1660       | 78.1720          | 78.2277    | 77.9553 | 77.8123       | 78.3967          | 78.1041    | 78.2726 | 78.3955 |
|                       |       |        | 364 | 74.7957       | 74.6069          | 74.6505    | 75.2929 | 74.9895       | 75.6149          | 75.8586    | 76.3462 | 75.8204       | 75.9019          | 75.9513    | 76.3789 | 76.0864 |
|                       |       |        | 728 | 74.7957       | 73.2178          | 73.0383    | 80.0800 | 79.4218       | 73.6853          | 73.6990    | 80.0599 | 79.3938       | 73.8943          | 73.7389    | 80.4688 | 79.9520 |

Figure 26: MAE on the wind power forecasts (DK2)

| Area                  | Dates | Window | W1  | W2<br>(asinh) | W2<br>(asinh-hp) | W2<br>(hp) | W3       | W3<br>(asinh) | W3<br>(asinh-hp) | W3<br>(hp) | W4       | W4<br>(asinh) | W4<br>(asinh-hp) | W4<br>(hp) |          |          |
|-----------------------|-------|--------|-----|---------------|------------------|------------|----------|---------------|------------------|------------|----------|---------------|------------------|------------|----------|----------|
|                       |       |        | 182 | 318.3849      | 290.3546         | 289.3503   | 287.5060 | 288.0211      | 292.1398         | 292.1897   | 290.2684 | 289.8196      | 292.8945         | 294.0494   | 291.4678 | 290.2309 |
| 2019.01.01-2019.12.31 |       |        | 364 | 318.3849      | 291.0473         | 288.4411   | 282.3725 | 283.6819      | 291.7512         | 289.4938   | 283.0420 | 284.2917      | 292.3236         | 290.1264   | 284.5274 | 285.1055 |
|                       |       |        | 728 | 318.3849      | 292.7880         | 291.1340   | 294.6650 | 294.8072      | 293.0215         | 291.2111   | 294.9754 | 295.0011      | 293.0429         | 291.1902   | 296.5663 | 295.5779 |
| 2019.01.01-2020.05.12 |       |        | 182 | 406.8696      | 321.3105         | 319.3540   | 317.2610 | 318.7936      | 323.8967         | 323.2104   | 321.1816 | 321.4703      | 324.1184         | 324.3939   | 322.2900 | 321.7824 |
|                       |       |        | 364 | 406.8696      | 330.3779         | 326.5089   | 319.1337 | 321.9901      | 331.4233         | 327.5756   | 320.6410 | 323.1410      | 331.7391         | 326.0553   | 321.8956 | 323.6097 |
| DK1                   |       |        | 728 | 406.8696      | 346.4224         | 341.3667   | 333.4185 | 336.1887      | 346.3990         | 341.3394   | 334.2268 | 336.6006      | 345.9703         | 340.2259   | 335.1776 | 337.0265 |
| 2019.05.13-2020.05.12 |       |        | 182 | 436.8404      | 327.2397         | 325.3969   | 321.7005 | 323.0743      | 329.8075         | 329.4912   | 326.0052 | 325.8949      | 329.7964         | 330.6365   | 327.0491 | 326.1218 |
|                       |       |        | 364 | 436.8404      | 340.3449         | 336.0647   | 324.7154 | 327.8384      | 341.2548         | 337.3300   | 326.1918 | 328.7467      | 341.3650         | 337.3970   | 327.4691 | 329.1208 |
|                       |       |        | 728 | 436.8404      | 362.4314         | 356.3375   | 335.7155 | 339.1086      | 362.0436         | 356.1661   | 336.0853 | 338.9054      | 361.5284         | 354.8008   | 337.4553 | 339.5970 |
| 2020.01.01-2020.05.12 |       |        | 182 | 584.5163      | 363.9593         | 390.0106   | 387.3483 | 390.9628      | 398.2488         | 398.0497   | 393.7399 | 395.5255      | 397.3669         | 395.8954   | 394.6986 | 395.6478 |
|                       |       |        | 364 | 584.5163      | 419.7010         | 412.5762   | 403.1498 | 409.0879      | 421.5320         | 415.0210   | 406.3270 | 411.3181      | 421.3738         | 414.6895   | 407.1943 | 411.1519 |
|                       |       |        | 728 | 584.5163      | 462.7041         | 451.3598   | 421.8613 | 429.7469      | 462.2330         | 451.1459   | 423.6569 | 430.5881      | 460.9918         | 448.0228   | 423.4215 | 430.7499 |

Figure 27: RMSE on the wind power forecasts (DK1)

| Area                  | Dates | Window   | W1       | W2       | W2<br>(asinh) | W2<br>(asinh-hp) | W2<br>(hp) | W3       | W3<br>(asinh) | W3<br>(asinh-hp) | W3<br>(hp) | W4       | W4<br>(asinh) | W4<br>(asinh-hp) | W4<br>(hp) |
|-----------------------|-------|----------|----------|----------|---------------|------------------|------------|----------|---------------|------------------|------------|----------|---------------|------------------|------------|
|                       |       |          | 182      | 364      | 728           | 182              | 364        | 728      | 182           | 364              | 728        | 182      | 364           | 728              | 182        |
| 2019.01.01-2019.12.31 | 182   | 89.6924  | 90.5770  | 91.3340  | 91.8347       | 90.9437          | 91.0369    | 92.0400  | 92.5017       | 91.3492          | 91.3910    | 92.3964  | 92.8075       | 91.6583          |            |
|                       |       | 89.6924  | 89.1968  | 89.5614  | 91.9816       | 91.2586          | 89.2972    | 89.7584  | 92.1715       | 91.2894          | 89.2374    | 89.8611  | 92.3191       | 91.3162          |            |
|                       | 364   | 89.6924  | 90.5253  | 90.0059  | 98.7990       | 97.7557          | 89.5193    | 90.0814  | 98.9810       | 97.8200          | 89.4642    | 90.0298  | 98.6669       | 97.6008          |            |
|                       | 728   | 89.6924  | 93.8419  | 94.3405  | 94.7405       | 94.1276          | 94.6971    | 95.4581  | 95.8298       | 94.9402          | 95.1074    | 95.8076  | 96.2354       | 95.3743          |            |
| 2019.01.01-2020.05.12 | 182   | 93.4372  | 93.8419  | 94.3405  | 94.7405       | 94.1276          | 94.6971    | 95.4581  | 95.8298       | 94.9402          | 95.1074    | 95.8076  | 96.2354       | 95.3743          |            |
|                       |       | 93.4372  | 92.4963  | 92.6865  | 94.7561       | 94.1766          | 92.8985    | 93.2715  | 95.3660       | 94.5679          | 92.9781    | 93.4070  | 95.5346       | 94.7055          |            |
|                       | 364   | 93.4372  | 93.8419  | 94.3405  | 94.7405       | 94.1276          | 94.6971    | 95.4581  | 95.8298       | 94.9402          | 95.1074    | 95.8076  | 96.2354       | 95.3743          |            |
|                       | 728   | 93.4372  | 92.5478  | 92.7518  | 100.8334      | 99.9302          | 92.7081    | 93.0374  | 101.1325      | 100.1066         | 92.7592    | 93.0468  | 101.0612      | 100.1567         |            |
| 2019.05.13-2020.05.12 | 182   | 93.6845  | 94.9894  | 95.6483  | 96.3194       | 95.5403          | 95.7659    | 96.6670  | 97.3150       | 96.2831          | 96.0474    | 96.9053  | 97.5625       | 96.5129          |            |
|                       |       | 93.6845  | 93.4505  | 93.6273  | 96.1939       | 95.6844          | 93.7752    | 94.0875  | 96.6889       | 96.0140          | 93.8709    | 94.1342  | 96.7499       | 96.1234          |            |
|                       | 364   | 93.6845  | 94.9894  | 95.6483  | 96.3194       | 95.5403          | 95.7659    | 96.6670  | 97.3150       | 96.2831          | 96.0474    | 96.9053  | 97.5625       | 96.5129          |            |
|                       | 728   | 93.6845  | 93.7661  | 93.8217  | 102.5378      | 101.8433         | 93.8442    | 93.9738  | 102.7134      | 101.9201         | 93.8533    | 93.9418  | 102.9080      | 102.1248         |            |
| 2020.01.01-2020.05.12 | 182   | 103.0172 | 102.2980 | 102.1376 | 102.2918      | 102.3577         | 104.0829   | 104.2645 | 104.4198      | 104.1612         | 104.6304   | 104.5992 | 105.0966      | 104.8981         |            |
|                       |       | 103.0172 | 100.9649 | 100.7660 | 101.9833      | 101.7556         | 102.1313   | 102.2947 | 103.0281      | 103.0306         | 102.5453   | 102.5102 | 103.8488      | 103.4377         |            |
|                       | 364   | 103.0172 | 100.3761 | 99.9005  | 106.2266      | 105.6682         | 100.9431   | 100.7048 | 106.8146      | 106.1078         | 101.2523   | 100.8641 | 107.3732      | 106.8575         |            |
|                       | 728   | 103.0172 | 100.3761 | 99.9005  | 106.2266      | 105.6682         | 100.9431   | 100.7048 | 106.8146      | 106.1078         | 101.2523   | 100.8641 | 107.3732      | 106.8575         |            |

Figure 28: RMSE on the wind power forecasts (DK2)

Forecasts for area DK1 were better in every period with best model W2, 364 window and asinh-hp transformation. Small difference was in the period 2020.01.01-2020.05.12 where best rolling window was 182.

| Area                      | Dates           | Model 1 | W1     | W2<br>182<br>asinh-hp | W2<br>364<br>asinh-hp | W2<br>728<br>asinh-hp | W3<br>182<br>asinh-hp | W3<br>364<br>asinh-hp | W3<br>728<br>asinh-hp | W4<br>182<br>asinh-hp | W4<br>364<br>asinh-hp | W4<br>728<br>asinh-hp | W1      | W2<br>182<br>hp | W2<br>364<br>hp | W2<br>728<br>hp | W3<br>182<br>hp | W3<br>364<br>hp | W3<br>728<br>hp | W4<br>182<br>hp | W4<br>364<br>hp | W4<br>728<br>hp |
|---------------------------|-----------------|---------|--------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|---------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                           |                 |         | 182    | 364                   | 728                   | 182                   | 364                   | 728                   | 182                   | 364                   | 728                   | 182                   | 364     | 728             | 182             | 364             | 728             |                 |                 |                 |                 |                 |
| DK1 2020.01.01-2020.05.12 | W1.182.asinh-hp | 0.000   | -1.777 | -6.592                | -7.508                | -12.741               | -12.843               | -5.179                | -4.943                | -8.337                | -9.003                | -13.256               | -13.319 | -6.714          | -5.762          | -8.484          | -8.826          | -13.249         | -13.300         |                 |                 |                 |
|                           | W1.182.hp       | 1.777   | 0.000  | -6.542                | -8.344                | -13.390               | -13.841               | -3.591                | -4.712                | -8.493                | -9.993                | -13.959               | -14.348 | -5.696          | -5.501          | -8.632          | -9.466          | -13.829         | -14.268         |                 |                 |                 |
|                           | W2.364.asinh-hp | 6.592   | 6.542  | 0.000                 | -4.130                | -15.229               | -15.857               | 2.418                 | 2.640                 | -4.640                | -6.257                | -14.681               | -15.002 | -0.138          | -0.146          | -4.914          | -5.578          | -14.101         | -14.711         |                 |                 |                 |
|                           | W2.364.hp       | 7.508   | 8.344  | 4.130                 | 0.000                 | -13.256               | -15.640               | 3.544                 | 4.105                 | -1.212                | -4.932                | -13.261               | -15.475 | 0.993           | 1.353           | -1.775          | -4.034          | -12.407         | -14.913         |                 |                 |                 |
|                           | W2.728.asinh-hp | 12.741  | 13.390 | 15.229                | 13.256                | 0.000                 | -4.121                | 9.341                 | 10.224                | 10.879                | 9.341                 | -3.098                | -5.049  | 6.629           | 7.147           | 9.981           | 8.944           | -2.368          | -4.698          |                 |                 |                 |
|                           | W2.728.hp       | 12.843  | 13.841 | 15.057                | 15.640                | 4.121                 | 0.000                 | 0.715                 | 10.791                | 11.419                | 11.354                | 0.58                  | -2.973  | 7.138           | 7.793           | 10.671          | 10.848          | 0.812           | -2.308          |                 |                 |                 |
|                           | W3.182.asinh-hp | 5.179   | 3.591  | -2.416                | -3.544                | -9.341                | -9.715                | 0.000                 | -0.136                | -4.759                | -5.607                | -10.470               | -10.607 | -4.071          | -2.820          | -5.022          | -5.355          | -10.473         | -10.600         |                 |                 |                 |
|                           | W3.182.hp       | 5.148   | 4.712  | -2.640                | -4.105                | -10.289               | -10.791               | 0.138                 | 0.000                 | -5.270                | -6.746                | -11.447               | -11.845 | -3.488          | -3.126          | -5.559          | -6.388          | -11.352         | -11.810         |                 |                 |                 |
|                           | W3.364.asinh-hp | 8.337   | 8.493  | 4.640                 | 1.212                 | -10.879               | -11.419               | 4.759                 | 5.270                 | 0.000                 | -3.485                | -13.483               | -13.337 | 1.633           | 1.983           | -1.805          | -2.738          | -12.993         | -13.134         |                 |                 |                 |
|                           | W3.364.hp       | 9.003   | 9.993  | 6.257                 | 4.932                 | -9.341                | -11.954               | 5.607                 | 6.746                 | 3.405                 | 0.000                 | -11.940               | -13.640 | 2.610           | 3.130           | 2.170           | 0.587           | -10.707         | -13.146         |                 |                 |                 |
|                           | W3.728.asinh-hp | 13.256  | 13.959 | 14.681                | 13.261                | 3.09                  | -0.584                | 10.470                | 11.434                | 13.483                | 11.490                | 0.000                 | -3.324  | 7.478           | 8.008           | 12.386          | 10.923          | 0.976           | -2.988          |                 |                 |                 |
|                           | W3.728.hp       | 13.319  | 14.348 | 15.092                | 15.475                | 5.049                 | 2.973                 | 10.607                | 11.845                | 13.337                | 13.640                | 3.224                 | 0.000   | 7.850           | 8.530           | 12.475          | 12.889          | 3.094           | 0.924           |                 |                 |                 |
|                           | W4.182.asinh-hp | 6.714   | 5.660  | 0.133                 | -0.993                | -6.629                | -7.163                | 4.074                 | 3.488                 | -1.633                | -2.610                | -7.478                | -7.850  | 0.000           | 0.738           | -1.969          | -2.558          | -7.324          | -7.749          |                 |                 |                 |
|                           | W4.182.hp       | 5.762   | 5.501  | -0.146                | -1.353                | -7.147                | -7.791                | 2.820                 | 3.126                 | -1.983                | -3.130                | -8.008                | -8.530  | -0.735          | 0.000           | -2.334          | -3.118          | -7.781          | -8.384          |                 |                 |                 |
|                           | W4.364.asinh-hp | 8.494   | 8.632  | 4.914                 | 1.775                 | -9.981                | -10.671               | 5.022                 | 5.559                 | 1.805                 | -2.170                | -12.386               | -12.475 | 1.969           | 2.334           | 0.000           | -2.053          | -12.018         | -12.375         |                 |                 |                 |
|                           | W4.364.hp       | 8.626   | 9.460  | 5.576                 | 4.034                 | -8.944                | -10.048               | 5.355                 | 6.388                 | 2.738                 | -0.587                | -10.923               | -12.093 | 2.558           | 3.118           | 2.053           | 0.000           | -10.191         | -12.201         |                 |                 |                 |
|                           | W4.728.asinh-hp | 13.248  | 13.829 | 14.101                | 12.408                | 2.368                 | -0.312                | 10.473                | 11.352                | 12.993                | 10.707                | -0.976                | -3.094  | 7.228           | 7.781           | 12.018          | 10.191          | 0.000           | -3.139          |                 |                 |                 |
|                           | W4.728.hp       | 13.300  | 14.269 | 14.711                | 14.913                | 4.698                 | 2.308                 | 10.600                | 11.810                | 13.134                | 13.146                | 2.988                 | -0.924  | 7.749           | 8.384           | 12.375          | 12.501          | 3.139           | 0.000           |                 |                 |                 |

Figure 29: Diebold-Mariano Test for wind power forecasts (DK1)

On the other hand best forecast was Nordpool's prognosis in the area DK2, except of period 2020.01.01-2020.05.12 where best model was Model W2, 728 window, asinh.

| Area | Dates                 | Model 1         | W2_182 | W2_182<br>asinh-<br>hp | W2_364 | W2_364<br>asinh-<br>hp | W2_728  | W2_728<br>asinh-<br>hp | W3_182 | W3_182<br>asinh-<br>hp | W3_364 | W3_364<br>asinh-<br>hp | W3_728  | W3_728<br>asinh-<br>hp | W4_182 | W4_182<br>asinh-<br>hp | W4_364 | W4_364<br>asinh-<br>hp | W4_728  | W4_728<br>asinh-<br>hp                                  |
|------|-----------------------|-----------------|--------|------------------------|--------|------------------------|---------|------------------------|--------|------------------------|--------|------------------------|---------|------------------------|--------|------------------------|--------|------------------------|---------|---|
| DK1  | 2020.01.01-2020.05.12 | W2.182.asinh-hp | 0.000  | -1.777                 | -6.592 | -7.508                 | -12.741 | -12.843                | -5.179 | -4.943                 | -8.337 | -9.003                 | -13.259 | -13.319                | -6.714 | -5.762                 | -8.484 | -8.626                 | -13.248 | -13.300   |
|      |                       | W2.182.hp       | 1.777  | 0.000                  | -6.542 | -8.344                 | -13.741 | -13.841                | -3.591 | -4.712                 | -8.493 | -9.993                 | -13.959 | -14.348                | -6.696 | -5.501                 | -8.632 | -9.460                 | -13.820 | <span style="background-color: #d9eaf7;">14.269</span>  |
|      |                       | W2.364.asinh-hp | 6.592  | 6.542                  | 0.000  | -4.130                 | 15.229  | -15.957                | 2.415  | 2.640                  | -6.460 | -8.257                 | 14.802  | 15.002                 | -1.139 | 0.146                  | -4.914 | -5.576                 | -14.101 | <span style="background-color: #d9eaf7;">14.711</span>  |
|      |                       | W2.364.hp       | 7.504  | 8.344                  | 4.130  | 0.000                  | -13.259 | -15.640                | 3.544  | 4.105                  | -1.212 | -4.932                 | -13.959 | -15.475                | 0.993  | 1.353                  | -1.775 | -4.034                 | -12.408 | <span style="background-color: #d9eaf7;">14.913</span>  |
|      |                       | W2.728.asinh-hp | 12.741 | 13.390                 | 15.229 | 15.256                 | 0.000   | -4.121                 | 9.341  | 10.224                 | 10.679 | 9.341                  | -3.098  | -5.049                 | 6.629  | 7.147                  | 9.981  | 9.844                  | -2.368  | <span style="background-color: #d9eaf7;">-4.698</span>  |
|      |                       | W2.728.hp       | 12.846 | 13.841                 | 15.057 | 15.640                 | 4.121   | 0.000                  | 9.715  | 10.791                 | 11.419 | 11.354                 | 3.584   | -2.073                 | 7.163  | 7.791                  | 10.671 | 10.848                 | 0.812   | <span style="background-color: #d9eaf7;">-2.308</span>  |
|      |                       | W3.182.asinh-hp | 5.177  | 3.591                  | -2.416 | -3.544                 | -9.341  | -9.715                 | 0.000  | 0.138                  | -4.759 | -5.607                 | -10.470 | -10.607                | -4.071 | -2.820                 | -5.022 | -5.355                 | -10.473 | <span style="background-color: #d9eaf7;">-10.600</span> |
|      |                       | W3.182.hp       | 4.943  | 4.712                  | -2.640 | -4.105                 | -10.224 | -10.791                | 0.136  | 0.000                  | -5.270 | -6.746                 | -11.433 | -11.845                | -3.488 | -3.126                 | -5.559 | -6.388                 | -11.352 | <span style="background-color: #d9eaf7;">-11.810</span> |
|      |                       | W3.364.asinh-hp | 8.337  | 8.403                  | 4.640  | 1.212                  | -10.879 | -11.419                | 4.759  | 5.270                  | 0.000  | -3.485                 | -13.449 | -13.337                | 1.633  | 1.983                  | -1.805 | -2.738                 | -12.993 | <span style="background-color: #d9eaf7;">-13.134</span> |
|      |                       | W3.364.hp       | 9.003  | 9.993                  | 6.257  | 4.932                  | -9.341  | -11.354                | 5.607  | 6.746                  | 3.485  | 0.000                  | -11.490 | -13.640                | 2.610  | 3.130                  | 2.170  | 0.587                  | -10.707 | <span style="background-color: #d9eaf7;">13.146</span>  |
|      |                       | W3.728.asinh-hp | 13.256 | 13.959                 | 14.681 | 13.261                 | 3.098   | -0.584                 | 10.470 | 11.433                 | 13.483 | 11.490                 | 0.000   | -3.324                 | 7.478  | 8.008                  | 12.386 | 10.923                 | 0.976   | <span style="background-color: #d9eaf7;">-2.988</span>  |
|      |                       | W3.728.hp       | 13.319 | 14.348                 | 15.002 | 15.475                 | 5.049   | 2.973                  | 10.607 | 11.845                 | 13.337 | 13.640                 | 3.324   | 0.000                  | 7.850  | 8.530                  | 12.475 | 12.693                 | 3.094   | <span style="background-color: #d9eaf7;">0.924</span>   |
|      |                       | W4.182.asinh-hp | 6.714  | 5.696                  | 0.133  | -0.993                 | -6.629  | -7.163                 | 4.071  | 3.488                  | -1.833 | -2.610                 | -7.478  | -7.850                 | 0.000  | 0.735                  | -1.969 | -2.558                 | -7.328  | <span style="background-color: #d9eaf7;">-7.749</span>  |
|      |                       | W4.182.hp       | 5.786  | 5.507                  | -0.146 | -1.353                 | -7.147  | -7.791                 | 2.820  | 3.126                  | -1.983 | -3.130                 | -8.004  | -8.530                 | -0.738 | 0.000                  | -2.334 | -3.118                 | -7.781  | <span style="background-color: #d9eaf7;">-8.384</span>  |
|      |                       | W4.364.asinh-hp | 8.484  | 8.832                  | 4.914  | 1.775                  | -9.981  | -10.671                | 5.022  | 5.559                  | 1.805  | -2.170                 | -12.386 | -12.475                | 1.969  | 2.334                  | 0.000  | -2.053                 | -12.018 | <span style="background-color: #d9eaf7;">-12.275</span> |
|      |                       | W4.364.hp       | 8.626  | 9.460                  | 5.576  | 4.034                  | -9.844  | -10.948                | 5.355  | 6.388                  | 2.738  | -0.587                 | -10.923 | -12.893                | 2.558  | 3.118                  | 2.053  | 0.000                  | -10.191 | <span style="background-color: #d9eaf7;">-12.501</span> |
|      |                       | W4.728.asinh-hp | 13.248 | 13.829                 | 14.101 | 12.408                 | 2.368   | -0.012                 | 10.474 | 11.352                 | 12.990 | 10.707                 | -0.976  | -3.094                 | 7.320  | 7.781                  | 12.018 | 10.191                 | 0.000   | <span style="background-color: #d9eaf7;">-3.139</span>  |
|      |                       | W4.728.hp       | 13.300 | 14.289                 | 14.711 | 14.913                 | 4.698   | 2.308                  | 10.600 | 11.810                 | 13.134 | 13.146                 | 2.988   | -0.924                 | 7.749  | 8.084                  | 12.375 | 12.501                 | 3.139   | 0.000   |

Figure 30: Diebold-Mariano Test for wind power forecasts (DK2)

### 5.3 Price forecasts

With more complex models results are much better, however *asinh* function surprisingly doesn't improve predictions in the every case. Disproportion is especially big in the last period (2020.01.01-2020.05.12) and Model 4.

I performed Model 5 hoping that with better predictions of wind power and consumption than original ones, price will be more accurate. Because these predictions replaced only values for prediction period, not rolling window, coefficients could be overfitted to the worse values trying to predict using improved ones.

| Area | Dates                 | Window | P1       | P1<br>(asinh) | P2      | P2<br>(asinh) | P2<br>(hp) | P2<br>(asinh-hp) | P3      | P3<br>(asinh) | P3<br>(asinh-hp) | P3<br>(hp) | P4      | P4<br>(asinh) | P4<br>(asinh-hp) | P4<br>(hp) | P5      | P5<br>(asinh) | P5<br>(asinh-hp) | P5<br>(hp) |         |
|------|-----------------------|--------|----------|---------------|---------|---------------|------------|------------------|---------|---------------|------------------|------------|---------|---------------|------------------|------------|---------|---------------|------------------|------------|---------|
| DK1  | 2019.01.01-2019.12.31 | 182    | 62.419   | 61.249        | 50.970  | 47.9628       | 47.7381    | 50.8575          | 45.5317 | 42.7631       | 42.6918          | 45.4616    | 41.8227 | 38.0530       | 37.9174          | 41.7375    | 41.9823 | 38.2650       | 38.0872          | 41.8347    |         |
|      |                       | 364    | 68.906   | 67.1030       | 49.816  | 47.5152       | 47.1734    | 49.4099          | 43.9993 | 41.3803       | 41.2459          | 43.4320    | 41.6006 | 38.0683       | 37.8144          | 41.1012    | 41.8993 | 38.2523       | 37.8048          | 41.1387    |         |
|      |                       | 728    | 59.616   | 59.895        | 48.2713 | 46.7990       | 48.2724    | 49.9277          | 42.2183 | 41.2856       | 42.2936          | 43.8182    | 38.5396 | 36.9538       | 38.0325          | 39.7222    | 38.6369 | 37.0154       | 37.6783          | 39.2963    |         |
|      |                       | 182    | 74.0371  | 73.7262       | 56.3047 | 52.4223       | 52.2724    | 54.1630          | 47.1442 | 49.2566       | 49.1521          | 47.0493    | 42.6386 | 40.1790       | 42.5200          | 42.7773    | 40.4663 | 40.2625       | 42.5822          |            |         |
|      |                       | 728    | 81.5801  | 83.1851       | 53.9097 | 51.3103       | 52.8048    | 53.7330          | 53.7251 | 44.5996       | 44.8034          | 45.3780    | 45.4885 | 40.1258       | 40.3976          | 40.0973    | 40.7431 | 40.4265       | 40.4869          | 40.9187    | 40.6592 |
|      |                       | 182    | 71.8941  | 72.5523       | 51.0392 | 50.3497       | 50.2518    | 50.9584          | 44.9798 | 43.8384       | 43.7886          | 44.9005    | 39.7074 | 38.6992       | 38.8401          | 39.7202    | 40.0723 | 39.9143       | 39.0115          | 39.9523    |         |
|      |                       | 728    | 90.3240  | 91.3046       | 50.4418 | 51.3177       | 50.9592    | 50.9019          | 42.7013 | 43.3715       | 43.3035          | 42.4294    | 38.6668 | 39.4514       | 39.3983          | 38.0728    | 39.3075 | 39.8022       | 39.2594          | 39.0516    |         |
|      |                       | 182    | 106.9217 | 108.0673      | 63.4542 | 64.9344       | 64.7159    | 63.3245          | 51.9698 | 52.1003       | 51.9040          | 51.3728    | 44.8903 | 46.5069       | 46.3744          | 44.6673    | 46.2144 | 47.4020       | 47.1833          | 45.9378    |         |
|      |                       | 728    | 121.8624 | 127.1532      | 65.1434 | 68.7022       | 68.2562    | 64.6577          | 51.1346 | 54.4576       | 53.8429          | 50.0724    | 44.4787 | 49.8485       | 49.5082          | 43.5445    | 46.4941 | 51.2276       | 50.4598          | 45.0910    |         |

Figure 31: MAE on the price forecasts (DK1)

| Area | Dates                 | Window | P1       | P1<br>(asinh) | P2      | P2<br>(asinh) | P2<br>(hp) | P2<br>(asinh-hp) | P3      | P3<br>(asinh) | P3<br>(asinh-hp) | P3<br>(hp) | P4      | P4<br>(asinh) | P4<br>(asinh-hp) | P4<br>(hp) | P5      | P5<br>(asinh) | P5<br>(asinh-hp) | P5<br>(hp) |  |
|------|-----------------------|--------|----------|---------------|---------|---------------|------------|------------------|---------|---------------|------------------|------------|---------|---------------|------------------|------------|---------|---------------|------------------|------------|--|
| DK2  | 2019.01.01-2019.12.31 | 182    | 60.6858  | 59.2051       | 47.1098 | 43.9585       | 43.8689    | 47.0197          | 42.8005 | 40.0418       | 40.0191          | 42.7953    | 40.8677 | 37.6311       | 37.5928          | 40.8462    | 40.9005 | 37.6356       | 37.5978          | 40.8793    |  |
|      |                       | 364    | 66.6403  | 65.8945       | 46.5398 | 43.7370       | 43.4099    | 46.2025          | 41.8642 | 39.1297       | 38.9770          | 41.6778    | 37.8993 | 37.7059       | 41.6324          | 41.7530    | 37.8815 | 37.6909       | 41.6208          |            |  |
|      |                       | 728    | 57.6415  | 58.9733       | 44.8386 | 42.8476       | 44.1264    | 46.0894          | 40.6209 | 38.8203       | 37.7410          | 41.6559    | 38.6653 | 36.5411       | 37.1855          | 39.1299    | 38.6469 | 36.5323       | 37.1654          | 39.1189    |  |
|      |                       | 182    | 72.0884  | 71.6346       | 50.7902 | 49.0337       | 48.9657    | 50.8620          | 44.9930 | 42.8715       | 42.8291          | 44.5599    | 42.4264 | 40.7061       | 40.6658          | 42.2127    | 42.1430 | 40.7024       | 40.6546          | 42.1068    |  |
|      |                       | 364    | 80.2821  | 81.0459       | 50.6433 | 49.8001       | 49.2566    | 50.3038          | 43.8488 | 42.6762       | 42.5482          | 43.6504    | 42.0346 | 41.3187       | 41.1618          | 42.8869    | 42.7766 | 41.1919       | 40.9892          | 42.5584    |  |
|      |                       | 728    | 84.4036  | 84.1260       | 49.7122 | 49.0534       | 49.6542    | 50.2275          | 42.9932 | 42.2209       | 42.7536          | 43.5251    | 42.7254 | 40.0093       | 40.3770          | 40.8931    | 40.4964 | 39.8414       | 40.1103          | 40.5446    |  |
|      |                       | 182    | 86.7053  | 89.2609       | 47.3317 | 47.0359       | 46.9511    | 47.4786          | 42.3404 | 41.4531       | 41.4567          | 42.3323    | 38.9638 | 38.6039       | 38.6062          | 38.8649    | 38.9773 | 38.5997       | 38.0029          | 38.9796    |  |
|      |                       | 364    | 86.0540  | 82.4595       | 49.1394 | 48.8246       | 47.9664    | 47.1719          | 41.8888 | 41.7497       | 41.6093          | 41.6284    | 41.1832 | 40.9705       | 40.3548          | 40.8640    | 41.1008 | 40.5398       | 40.3338          | 40.8050    |  |
|      |                       | 728    | 86.5022  | 88.1669       | 47.3644 | 47.3026       | 47.0905    | 46.9668          | 41.1247 | 40.7357       | 40.7012          | 40.7480    | 38.9678 | 38.7112       | 38.5777          | 38.4644    | 38.9391 | 38.6893       | 38.5667          | 38.4436    |  |
|      |                       | 182    | 103.3811 | 105.5011      | 60.9066 | 63.0742       | 62.9344    | 59.3047          | 49.8122 | 50.6371       | 50.5406          | 49.4027    | 46.0072 | 49.1450       | 49.0993          | 45.9630    | 45.9220 | 49.1134       | 49.0715          | 45.8823    |  |
|      |                       | 364    | 117.7113 | 122.6263      | 61.9195 | 65.8606       | 65.3047    | 61.4044          | 49.2951 | 52.4168       | 52.3527          | 49.0651    | 48.4499 | 50.7027       | 50.6438          | 46.2558    | 46.4197 | 50.5733       | 50.5722          | 46.1935    |  |
|      |                       | 728    | 157.8496 | 158.5767      |         |               |            |                  |         |               |                  |            |         |               |                  |            |         |               |                  |            |  |

| Area                  | Dates | Window            | P1<br>(asinh)   | P1<br>(hp)      | P2<br>(asinh)   | P2<br>(hp)      | P2<br>(asinh-<br>hp) | P2<br>(hp)              | P3<br>(asinh)           | P3<br>(hp)              | P3<br>(asinh-<br>hp) | P3<br>(hp) | P4<br>(asinh) | P4<br>(hp) | P4<br>(asinh-<br>hp) | P4<br>(hp) | P5<br>(asinh) | P5<br>(hp) | P5<br>(asinh-<br>hp) | P5<br>(hp) |
|-----------------------|-------|-------------------|-----------------|-----------------|-----------------|-----------------|----------------------|-------------------------|-------------------------|-------------------------|----------------------|------------|---------------|------------|----------------------|------------|---------------|------------|----------------------|------------|
| 2019.01.01-2019.12.31 | 182   | 85.8074 85.8970   | 71.0183 69.5550 | 69.3800 70.8613 | 64.0467 62.1807 | 62.0847 63.9167 | 57.3221 55.4134      | 55.3484 57.2886         | 57.3526 55.4122         | 55.3482 57.3192         |                      |            |               |            |                      |            |               |            |                      |            |
|                       | 364   | 90.9438 90.9558   | 70.8978 69.1326 | 68.6577 70.4699 | 63.1184 60.7418 | 60.3206 62.7093 | 58.5958 55.9306      | 55.5864 58.3923 58.5748 | 55.9183 56.9119 56.4230 | 55.2277 55.9161 56.9174 |                      |            |               |            |                      |            |               |            |                      |            |
|                       | 728   | 81.6979 81.8286   | 68.4909 67.7287 | 68.0290 70.1321 | 62.1157 60.2596 | 60.1666 62.5522 | 58.4280 55.2235      | 55.3944 56.9119 56.4230 | 55.2277 55.9161 56.9174 |                         |                      |            |               |            |                      |            |               |            |                      |            |
|                       | 182   | 97.5207 98.3094   | 72.8778 72.4752 | 72.2986 72.7138 | 64.9567 63.4434 | 63.3412 64.4372 | 58.3892 57.7596      | 57.6712 58.2822 58.3666 | 57.8722 57.8079 57.8079 | 57.8722 57.8079 57.8079 |                      |            |               |            |                      |            |               |            |                      |            |
| 2019.05.01-2020.05.12 | 182   | 105.054 106.9854  | 72.8930 72.3990 | 72.4667 72.4696 | 63.9053 63.1275 | 63.4221 63.7303 | 59.4980 58.7303      | 58.4707 59.1991 59.2922 | 58.6997 58.3870 59.0117 |                         |                      |            |               |            |                      |            |               |            |                      |            |
|                       | 728   | 114.4661 114.6168 | 72.4238 72.3496 | 71.9927 72.4006 | 63.3747 62.6380 | 62.3413 63.3847 | 57.8393 58.0554      | 57.9887 57.9600 57.7600 | 57.9887 57.7600 57.7600 | 57.8120 57.7323         |                      |            |               |            |                      |            |               |            |                      |            |
|                       | 182   | 81.7205 93.0093   | 64.4069 65.1309 | 65.0196 64.8052 | 58.4133 57.8041 | 57.7664 58.3409 | 53.6282 53.5496      | 53.5471 53.0251 53.0422 | 53.5520 53.5048         | 53.5520 53.5048         |                      |            |               |            |                      |            |               |            |                      |            |
|                       | 364   | 103.4034 105.6744 | 65.2551 66.6613 | 66.2343 64.7711 | 57.5874 56.0733 | 57.8036 57.2014 | 54.9553 55.0733      | 54.8478 54.6032 54.8622 | 55.0473 54.8302 54.5312 |                         |                      |            |               |            |                      |            |               |            |                      |            |
| 2019.05.13-2020.05.12 | 728   | 118.2235 118.0664 | 65.1960 66.6624 | 65.5080 65.8200 | 57.3580 57.4808 | 57.9015 56.6580 | 52.9274 53.7103      | 53.4340 52.2840 52.8748 | 53.8894 53.4312 52.2605 |                         |                      |            |               |            |                      |            |               |            |                      |            |
|                       | 182   | 124.1372 126.2520 | 72.7386 72.3990 | 72.4667 72.4696 | 63.9053 63.1275 | 63.4221 63.7303 | 59.8449 58.7303      | 58.4707 59.1991 59.2922 | 58.6997 58.3870 59.0117 |                         |                      |            |               |            |                      |            |               |            |                      |            |
|                       | 364   | 136.4776 140.9381 | 79.1074 82.4876 | 82.0164 77.6381 | 65.6535 69.2530 | 69.0952 65.3398 | 61.9820 65.8046      | 65.7319 61.3899 61.4912 | 65.7225 65.6507 61.2735 |                         |                      |            |               |            |                      |            |               |            |                      |            |
|                       | 728   | 175.3421 175.5383 | 79.9217 81.8020 | 81.8901 78.6005 | 66.7081 68.7556 | 67.9527 65.6152 | 61.5466 65.1980      | 64.5768 60.7434 61.4133 | 65.1216 64.5043 60.6200 |                         |                      |            |               |            |                      |            |               |            |                      |            |

Figure 33: RMSE on the price forecasts (DK1)

| Area                  | Dates | Window            | P1<br>(asinh)   | P1<br>(hp)      | P2<br>(asinh)   | P2<br>(hp)      | P2<br>(asinh-<br>hp) | P2<br>(hp)              | P3<br>(asinh)           | P3<br>(hp)              | P3<br>(asinh-<br>hp) | P3<br>(hp) | P4<br>(asinh) | P4<br>(hp) | P4<br>(asinh-<br>hp) | P4<br>(hp) | P5<br>(asinh) | P5<br>(hp) | P5<br>(asinh-<br>hp) | P5<br>(hp) |
|-----------------------|-------|-------------------|-----------------|-----------------|-----------------|-----------------|----------------------|-------------------------|-------------------------|-------------------------|----------------------|------------|---------------|------------|----------------------|------------|---------------|------------|----------------------|------------|
| 2019.01.01-2019.12.31 | 182   | 85.8074 85.8970   | 71.0183 69.5550 | 69.3800 70.8613 | 64.0467 62.1807 | 62.0847 63.9167 | 57.3221 55.4134      | 55.3484 57.2886         | 57.3526 55.4122         | 55.3482 57.3192         |                      |            |               |            |                      |            |               |            |                      |            |
|                       | 364   | 90.9438 90.9558   | 70.8978 69.1326 | 68.6577 70.4699 | 63.1184 60.7418 | 60.3206 62.7093 | 58.5958 55.9306      | 55.5864 58.3923 58.5748 | 55.9183 56.9119 56.4230 | 55.2277 55.9161 56.9174 |                      |            |               |            |                      |            |               |            |                      |            |
|                       | 728   | 81.6979 81.8286   | 68.4909 67.7287 | 68.0290 70.1321 | 62.1157 60.2596 | 60.1666 62.5522 | 58.4280 55.2235      | 55.3944 56.9119 56.4230 | 55.2277 55.9161 56.9174 |                         |                      |            |               |            |                      |            |               |            |                      |            |
|                       | 182   | 97.5207 98.3094   | 72.8778 72.4752 | 72.2986 72.7138 | 64.9567 63.4434 | 63.3412 64.4372 | 58.3892 57.7596      | 57.6712 58.2822 58.3666 | 57.8722 57.8079 57.8079 | 57.8722 57.8079 57.8079 |                      |            |               |            |                      |            |               |            |                      |            |
| 2019.05.13-2020.05.12 | 182   | 105.054 106.9854  | 72.8930 72.3990 | 72.4667 72.4696 | 63.9053 63.1275 | 63.4221 63.7303 | 59.8449 58.7303      | 58.4707 59.1991 59.2922 | 58.6997 58.3870 59.0117 |                         |                      |            |               |            |                      |            |               |            |                      |            |
|                       | 364   | 108.054 106.9854  | 72.8930 72.3990 | 72.4667 72.4696 | 63.9053 63.1275 | 63.4221 63.7303 | 59.8449 58.7303      | 58.4707 59.1991 59.2922 | 58.6997 58.3870 59.0117 |                         |                      |            |               |            |                      |            |               |            |                      |            |
|                       | 728   | 114.4661 114.6168 | 72.4238 72.3496 | 71.9927 72.4006 | 63.3747 62.6380 | 62.3413 63.3847 | 57.8393 58.0554      | 57.9887 57.9600 57.7600 | 57.9887 57.7600 57.7600 | 57.8120 57.7323         |                      |            |               |            |                      |            |               |            |                      |            |
|                       | 182   | 91.7205 93.0093   | 64.4069 65.1309 | 65.0196 64.8052 | 58.4133 57.8041 | 57.7664 58.3409 | 53.6282 53.5496      | 53.5471 53.0251 53.0422 | 53.5520 53.5048         | 53.5520 53.5048         |                      |            |               |            |                      |            |               |            |                      |            |
| 2019.05.13-2020.05.12 | 364   | 101.4034 105.6744 | 65.2551 66.6613 | 66.2343 64.7711 | 57.5874 56.0733 | 57.8036 57.2014 | 54.9553 55.0733      | 55.0733 54.8478 54.6032 | 54.8622 55.0473         |                         |                      |            |               |            |                      |            |               |            |                      |            |
|                       | 728   | 118.2235 118.0664 | 65.1960 66.6624 | 65.5080 65.8200 | 57.3580 57.4808 | 57.9015 56.6580 | 52.9274 53.7103      | 53.4340 52.2840 52.8748 | 53.8894 53.4312 52.2605 |                         |                      |            |               |            |                      |            |               |            |                      |            |
|                       | 182   | 124.1372 126.2520 | 72.7386 72.3990 | 72.4667 72.4696 | 63.9053 63.1275 | 63.4221 63.7303 | 59.8449 58.7303      | 58.4707 59.1991 59.2922 | 58.6997 58.3870 59.0117 |                         |                      |            |               |            |                      |            |               |            |                      |            |
|                       | 364   | 136.4776 140.9381 | 79.1074 82.4876 | 82.0164 77.6381 | 65.6535 69.2530 | 69.0952 65.3398 | 61.5620 65.8046      | 65.7319 61.3899 61.4912 | 65.7225 65.6507 61.2735 |                         |                      |            |               |            |                      |            |               |            |                      |            |
| 2020.01.01-2020.05.12 | 728   | 175.3421 175.5383 | 79.9217 81.8020 | 81.8901 78.6005 | 66.7081 68.7556 | 67.9527 65.6152 | 61.5466 65.1980      | 64.5768 60.7434 61.4133 | 65.1216 64.5043 60.6200 |                         |                      |            |               |            |                      |            |               |            |                      |            |

Figure 34: RMSE on the price forecasts (DK2)

Best performing models for area DK1 were differential and Model P5 was best only in one period. In some settings there was no significant difference between models P5 and P4. IN the both areas best length of rolling window was 728.

- 2019.01.01-2019.12.31: Model P4, 728 window, Asinh
- 2019.05.13-2020.05.12: Model P5, 728 window, HP
- 2019.01.01-2020.05.12: Model P4, 728 window, None
- 2020.01.01-2020.05.12: Model P4, 728 window, HP

| Area            | Dates                 | Model 1         | P4<br>182<br>asinh  | P4<br>182<br>hp | P4<br>364<br>asinh | P4<br>364<br>hp | P4<br>728<br>asinh | P4<br>728<br>hp | P4<br>728<br>asinh-<br>hp | P4<br>728<br>hp | P5<br>182<br>asinh | P5<br>182<br>hp | P5<br>364<br>asinh | P5<br>364<br>hp | P5<br>728<br>asinh | P5<br>728<br>hp | P5<br>728<br>asinh-<br>hp | P5<br>728<br>hp |         |         |         |
|-----------------|-----------------------|-----------------|---------------------|-----------------|--------------------|-----------------|--------------------|-----------------|---------------------------|-----------------|--------------------|-----------------|--------------------|-----------------|--------------------|-----------------|---------------------------|-----------------|---------|---------|---------|
| DK1             | 2020.01.01-2020.05.12 | P4.182          | 0.000 -5.871 -5.401 | 10.142          | -12.859            | -12.506         | -5.698             | 1.053           | -9.402                    | -8.576          | 3.635              | -12.900         | -8.840             | -8.099          | 10.096             | -4.812          | -12.438                   | -10.936         | -0.717  |         |         |
|                 |                       | P4.182.asinh    | 5.871               | 0.000           | 6.768              | 6.481           | -12.737            | -12.288         | 0.466                     | 5.140           | -7.737             | -6.700          | 7.355              | 0.974           | -9.060             | -6.924          | 1.883                     | 0.060           | -11.677 | -9.721  | 3.712   |
|                 |                       | P4.182.asinh-hp | 5.401               | -6.768          | 0.000              | -13.001         | -12.597            | 0.076           | 4.778                     | -7.999          | -6.977             | 5.096           | 0.532              | -9.980          | -6.220             | 1.447           | -0.285                    | -11.888         | -9.961  | 3.348   |         |
|                 |                       | P4.182.hp       | 10.142              | -6.481          | -6.031             | -13.001         | -12.597            | -6.298          | 0.531                     | -9.711          | -8.860             | 3.113           | 14.021             | -9.421          | -8.714             | -12.146         | -5.291                    | -12.712         | -11.234 | -1.253  |         |
| P4.364.asinh    |                       | P4.364.asinh    | 12.859              | 12.737          | 13.001             | 13.165          | 0.000              | 6.630           | 12.453                    | 13.881          | 2.203              | 2.919           | 15.401             | 9.621           | 9.708              | 10.268          | 10.138                    | 10.115          | -2.047  | 0.604   | 13.137  |
|                 |                       | P4.364.asinh-hp | 12.506              | 12.288          | 12.597             | 12.831          | -6.630             | 0.000           | 11.878                    | 12.400          | 16.101             | 2.400           | 15.047             | 9.200           | 9.112              | 9.712           | 9.734                     | 9.554           | -2.811  | -0.135  | 12.650  |
|                 |                       | P4.364.hp       | 5.698               | -0.466          | -0.768             | -12.453         | -11.878            | 0.000           | 6.103                     | -13.419         | -12.725            | -6.398          | 8.810              | 0.473           | -3.085             | -2.424          | 1.452                     | -0.516          | -11.118 | -9.258  | 4.983   |
|                 |                       | P4.728.asinh    | -1.053              | -5.140          | -4.778             | -13.881         | -13.450            | -6.103          | 0.000                     | -13.419         | -14.767            | -15.432         | -14.556            | 0.000           | -6.757             | -9.111          | -8.578                    | -6.039          | -15.828 | -18.470 | -0.725  |
| P4.728.asinh-hp |                       | P4.728.asinh-hp | 8.576               | 6.700           | 8.877              | 8.890           | -2.919             | -2.400          | 6.303                     | 12.271          | -4.031             | 0.000           | 14.556             | 5.763           | 4.346              | 4.793           | 6.254                     | 6.846           | -7.801  | -5.614  | 10.262  |
|                 |                       | P4.728.hp       | -3.635              | -7.355          | -7.006             | -3.113          | -15.401            | -15.047         | -8.610                    | -14.767         | -15.432            | -14.556         | 0.000              | -6.757          | -9.111             | -8.578          | -6.039                    | -15.828         | -18.470 | -0.725  | -11.017 |
|                 |                       | P5.182.asinh    | 12.900              | 11.077          | 11.888             | 12.712          | 2.047              | 2.811           | 0.000                     | 8.793           | 11.118             | 17.009          | 8.313              | 7.801           | 18.470             | 9.578           | 9.172                     | 10.032          | 12.692  | 0.      |         |

In the area DK2 best performing model was Model P5 in every period, however again in some settings there was no big difference compared to the Model P4.

- 2019.01.01-2019.12.31: Model P5, 728 window, Asinh
- 2019.05.13-2020.05.12: Model P5, 728 window, HP
- 2019.01.01-2020.05.12: Model P5, 728 window, Asinh
- 2020.01.01-2020.05.12: Model P5, 728 window, HP

| Area | Dates                 | Model 1         | P4_182<br>asinh | P4_182<br>asinh-hp | P4_364<br>asinh | P4_364<br>asinh-hp | P4_728<br>asinh | P4_728<br>asinh-hp | P5_182<br>asinh | P5_182<br>asinh-hp | P5_364<br>asinh | P5_364<br>asinh-hp | P5_728<br>asinh | P5_728<br>asinh-hp | P5_728<br>hp |         |        |         |       |
|------|-----------------------|-----------------|-----------------|--------------------|-----------------|--------------------|-----------------|--------------------|-----------------|--------------------|-----------------|--------------------|-----------------|--------------------|--------------|---------|--------|---------|-------|
|      |                       | P4.182          | 0.000           | -10.694            | -10.520         | 4.671              | -1.651          | -10.221            | -10.105         | -0.965             | -6.734          | 5.996              | 0.711           | 4.100              | 10.563       | -10.405 |        |         |       |
|      |                       | P4.182.asinh    | 10.694          | 0.000              | 3.714           | 10.839             | 7.346           | -4.761             | -4.601          | 6.429              | -0.944          | 0.024              | 7.959           | 10.936             | 1.826        | 3.572   | 5.658  | -9.972  |       |
|      |                       | P4.182.asinh-hp | 10.520          | -3.714             | 0.000           | 10.674             | 7.237           | -4.921             | -4.766          | 6.333              | -1.056          | -0.089             | 7.871           | 10.762             | -0.659       | 1.645   | 10.905 | -4.595  |       |
|      |                       | P4.182.hp       | -4.671          | -10.839            | -10.674         | 0.000              | -1.802          | -10.312            | -10.200         | -1.089             | -6.819          | -6.080             | 0.959           | 1.76               | -10.707      | -10.599 | 4.002  | -10.066 |       |
|      |                       | P4.364          | 1.651           | -7.344             | -7.237          | 1.802              | 0.000           | -12.905            | -12.670         | 0.386              | -6.748          | -5.828             | 2.486           | 1.908              | -7.202       | -7.106  | 2.045  | -12.449 |       |
|      |                       | P4.364.asinh    | 10.221          | 4.761              | 4.921           | 10.312             | 12.905          | 0.000              | 2.767           | 10.431             | 3.560           | 4.683              | 11.787          | 4.085              | 4.953        | 10.415  | 4.799  | 10.699  | 3.723 |
|      |                       | P4.364.asinh-hp | 10.105          | 4.601              | 4.766           | 10.200             | 12.670          | -2.767             | 0.000           | 10.322             | 3.384           | 4.530              | 11.659          | 10.217             | 4.847        | 4.800   | 10.305 | 4.048   |       |
|      |                       | P4.728          | 0.965           | -6.424             | -6.333          | 1.800              | -0.380          | -10.431            | -10.322         | 0.000              | -8.401          | -7.410             | 13.938          | 1.167              | -6.315       | -6.230  | 1.273  | -10.139 |       |
|      |                       | P4.728.asinh    | 6.738           | 0.944              | 1.000           | 6.819              | 6.748           | -3.560             | -3.384          | 8.481              | 0.000           | 8.020              | 10.059          | 6.857              | 1.015        | 1.117   | 6.932  | -3.190  | 8.783 |
|      |                       | P4.728.asinh-hp | 5.998           | -0.024             | 0.889           | 6.000              | 5.826           | -4.683             | -4.530          | 7.410              | -8.000          | 0.000              | 9.136           | 6.122              | 0.054        | 0.157   | 6.199  | -4.341  |       |
|      |                       | P4.728.hp       | -0.711          | -7.959             | -7.871          | -0.599             | -2.495          | -11.730            | -11.655         | -13.528            | -10.109         | -9.139             | 0.000           | -0.498             | -7.840       | -7.762  | -0.386 | -11.473 |       |
|      |                       | P5.182          | -4.100          | -10.936            | -10.762         | -1.760             | -1.908          | -10.331            | -10.217         | -1.167             | -6.857          | -6.122             | 0.488           | 0.000              | 10.842       | -10.682 | 4.256  | -10.099 |       |
|      |                       | P5.182.asinh    | 10.563          | -1.826             | 0.659           | 10.777             | 7.022           | -4.805             | -4.647          | 6.318              | -1.051          | -0.094             | 7.849           | 10.842             | 0.000        | 3.409   | 10.974 | -4.473  |       |
|      |                       | P5.182.asinh-hp | 10.405          | -3.572             | -1.645          | 10.558             | 7.106           | -4.953             | -4.800          | 6.230              | -1.117          | -0.157             | 7.762           | 10.682             | -3.409       | 0.000   | 10.823 | -4.628  |       |
|      |                       | P5.182.hp       | -5.958          | -11.070            | -10.999         | -4.002             | -2.045          | -10.415            | -10.305         | -1.273             | -6.932          | -6.199             | 0.396           | -4.256             | -10.074      | -10.823 | 0.000  | -10.178 |       |
|      |                       | P5.364          | 0.972           | 4.420              | 4.584           | 10.089             | 12.449          | -4.795             | -4.048          | 10.136             | 3.190           | 4.34               | 11.474          | 10.090             | 4.473        | 4.625   | 10.178 | 0.000   |       |
|      |                       | P5.364.asinh    | 6.738           | -0.688             | -6.592          | 0.824              | -0.725          | -10.096            | -10.587         | -7.563             | -8.763          | -7.710             | 11.234          | 0.915              | -6.574       | -6.489  | 1.021  | -10.409 |       |
|      |                       | P5.364.asinh-hp | 6.613           | 0.731              | 0.903           | 6.694              | 6.588           | -3.723             | -3.548          | 0.252              | -3.528          | -6.647             | 9.875           | 6.735              | 0.983        | 0.966   | 6.810  | -3.361  |       |
|      |                       | P5.728          | 5.888           | -0.157             | -0.044          | 5.971              | 5.690           | -4.816             | -4.664          | 7.214              | -8.409          | 3.071              | 8.933           | 6.016              | -0.079       | 0.024   | 6.093  | -4.484  |       |
|      |                       | P5.728.asinh    | -0.954          | 8.202              | -8.113          | -0.843             | -2.806          | -11.972            | -11.898         | -14.721            | -10.387         | -9.419             | -7.028          | -9.728             | -8.083       | -8.005  | -8.628 | -11.722 |       |
|      |                       | P5.728.hp       |                 |                    |                 |                    |                 |                    |                 |                    |                 |                    |                 |                    |              |         |        |         |       |
| DK2  | 2020.01.01-2020.05.12 |                 |                 |                    |                 |                    |                 |                    |                 |                    |                 |                    |                 |                    |              |         |        |         |       |

Figure 36: Diebold-Mariano Test for price forecasts (DK2)

## 5.4 Results summary

In following table there are included settings of models for the best result for each area and period of consumption, wind power and price forecast.

| area | period                | consumption | wind power      | price           |
|------|-----------------------|-------------|-----------------|-----------------|
| DK1  | 2019.01.01-2019.12.31 | C4.728      | W2.364.asinh-hp | P4.728.asinh    |
| DK1  | 2019.05.13-2020.05.12 | C4.728      | W2.364.asinh-hp | P5.728.hp       |
| DK1  | 2019.01.01-2020.05.12 | C4.728      | W2.364.asinh-hp | P4.728          |
| DK1  | 2020.01.01-2020.05.12 | C4.728      | W2.182.asinh-hp | P4.728.hp       |
| DK2  | 2019.01.01-2019.12.31 | C3.728      |                 | W1 P5.728.asinh |
| DK2  | 2019.05.13-2020.05.12 | C3.364.hp   |                 | W1 P5.728.hp    |
| DK2  | 2019.01.01-2020.05.12 | C3.364.hp   |                 | W1 P5.728.asinh |
| DK2  | 2020.01.01-2020.05.12 | C3.182.hp   |                 | W1 P5.728.hp    |

Table 4: Best settings of models.

## 6 Conclusions

Almost all of the assumptions came true, forecasts for consumption and partially for wind power have been performed better than original prepared by Nordpool. Even models for wind power performed well however it is not typical time-series problem, because more important factors influencing such as atmospheric models were not known and not used in this work.

Main finding is that period of forecast matters in using the most efficient model. For some periods more accurate were shorter calibration windows, because anomalies in the 2020 caused by COVID-19 changed seasonal trends like consumption and thus price which was significantly lower in 2020 than 2019.

One assumption I found invalid was that *asinh* normalization function improves price predictions. It does but not for 2020 year where *asinh* and *asinh-hp* normalization fails with every length of calibration window. It also fails for wind power DK2 where power production is probably too low to have impact on the seasonal trend, thus mostly best forecast is provided by Nordpool. In the area DK1 best forecasts used *asinh-hp* transformation and no other forecasts and areas used this transformation as the best one. Other used either *asinh* or *hp* filter. not both.

Experiment of replacing original forecasts of Nordpool with better, forecasted results unfortunately failed but I still see potential with bigger calibration window, which can be used to trained better forecasts for whole considering period of price prediction. But for this purpose it's necessary to have more data. However for DK2 Model P5 has better performance, this model uses original wind power forecast so it's not know very different from Model P4.

There are still some questions that should be resolved to receive better forecasts and I think the biggest one is to find relation between area DK1 and DK2, because for now there is no one universal model for both areas. Knowing this relation should get profits in predicting more accurate prices for electricity.

## 7 Appendix

### 7.1 Diebolt-Mariano test results

#### 7.1.1 Consumption forecasts

| Area | Dates                 | Model 1      | C1<br>728 | C2<br>182<br>asinh | C2<br>364<br>asinh | C2<br>728 | C2<br>728<br>asinh | C3<br>182<br>asinh | C3<br>364<br>asinh | C3<br>728<br>asinh | C4<br>182<br>asinh | C4<br>364<br>asinh | C4<br>728<br>asinh |        |        |       |
|------|-----------------------|--------------|-----------|--------------------|--------------------|-----------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------|--------|-------|
|      |                       | C1.728       | 0.000     | 12.212             | 9.854              | 19.451    | 17.426             | 21.261             | 20.259             | 9.082              | 6.609              | 11.446             | 10.021             | 21.232 | 19.954 |       |
|      |                       | C2.182       | -12.212   | 0.000              | -5.278             | 6.492     | 5.191              | 7.179              | 6.097              | -5.577             | -8.438             | 5.341              | 3.794              | 7.608  | 6.343  |       |
|      |                       | C2.182.asinh | -9.854    | 5.278              | 0.000              | 6.285     | 7.607              | 8.882              | 8.202              | -1.111             | -5.938             | 7.216              | 6.102              | 9.213  | 8.342  |       |
|      |                       | C2.364       | -18.451   | -6.492             | -8.285             | 0.000     | -2.631             | 2.659              | 0.465              | -8.655             | 10.655             | 0.729              | -2.619             | 3.465  | 1.396  |       |
|      |                       | C2.364.asinh | -17.436   | -5.191             | -7.179             | -1.607    | 2.631              | 0.000              | 3.787              | 2.376              | -7.638             | 10.059             | 0.814              | -1.394 | 4.352  | 2.793 |
|      |                       | C2.728       | -21.381   | -7.179             | -9.882             | -2.659    | -3.787             | 0.000              | -3.458             | -9.251             | -11.191            | -2.295             | -3.736             | 2.188  | -0.471 |       |
|      |                       | C2.728.asinh | -20.259   | -6.097             | -4.202             | -0.445    | -2.376             | -3.458             | 0.000              | -8.379             | -10.983            | -0.862             | -2.656             | 3.732  | 1.520  |       |
|      |                       | C3.182       | -0.083    | 5.577              | 1.111              | 0.659     | 7.835              | 9.251              | 8.279              | 0.000              | -5.800             | 9.486              | 7.738              | 10.662 | 9.546  |       |
|      |                       | C3.182.asinh | -6.689    | 8.438              | -9.538             | 10.055    | 10.058             | 11.191             | 10.583             | 5.800              | 0.000              | 11.290             | 10.490             | 12.381 | 11.764 |       |
| DK1  | 2019.01.01-2019.12.31 | C3.364       | -17.346   | -5.341             | -7.216             | 0.729     | -0.814             | 2.295              | 0.862              | -9.486             | -11.290            | 0.000              | -3.411             | 4.618  | 2.247  |       |
|      |                       | C3.364.asinh | -16.021   | -3.794             | -4.102             | 2.619     | 1.384              | 3.736              | 2.656              | -7.738             | -10.490            | 3.411              | 0.000              | 5.772  | 4.614  |       |
|      |                       | C3.728       | -21.292   | -7.009             | -9.213             | -3.465    | -4.352             | -2.188             | -3.733             | -10.662            | -12.381            | -4.616             | -5.772             | 0.000  | -3.690 |       |
|      |                       | C4.182       | -19.954   | -6.343             | -8.342             | 1.396     | -2.793             | 0.471              | -1.287             | -5.946             | -11.764            | -2.247             | -4.614             | 3.690  | 0.000  |       |
|      |                       | C4.182.asinh | -18.196   | 6.116              | 2.141              | 9.011     | 8.100              | 9.576              | 8.792              | 2.646              | -3.318             | 9.731              | 8.191              | 10.869 | 9.876  |       |
|      |                       | C4.364       | -17.346   | -5.341             | -7.216             | 0.729     | -0.814             | 2.295              | 0.862              | -9.486             | -11.290            | 0.000              | -3.411             | 4.618  | 2.247  |       |
|      |                       | C4.364.asinh | -16.786   | -4.741             | -6.704             | 1.255     | -0.170             | 2.591              | 1.287              | -8.736             | -10.891            | 1.213              | -1.872             | 4.562  | 2.571  |       |
|      |                       | C4.728       | -21.452   | -7.915             | -9.509             | -4.018    | -4.837             | -2.930             | -4.272             | -9.017             | -12.641            | -5.140             | -6.211             | -2.053 | -4.203 |       |
|      |                       | C4.728.asinh | -20.011   | -6.500             | -4.506             | -1.739    | -3.096             | -0.065             | -1.927             | -6.644             | -11.884            | -2.571             | -4.807             | 2.240  | -1.211 |       |

Figure 37: Diebold-Mariano Test for consumption forecasts (DK1)

| Area | Dates                 | Model 1      | C1<br>728 | C2<br>182<br>asinh | C2<br>364<br>asinh | C2<br>728 | C2<br>728<br>asinh | C3<br>182<br>asinh | C3<br>364<br>asinh | C3<br>728<br>asinh | C4<br>182<br>asinh | C4<br>364<br>asinh | C4<br>728<br>asinh |        |        |
|------|-----------------------|--------------|-----------|--------------------|--------------------|-----------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------|--------|
|      |                       | C1.728       | 0.000     | 10.844             | 8.922              | 16.192    | 15.679             | 19.205             | 19.494             | 8.200              | 6.362              | 14.976             | 14.213             | 18.802 | 18.010 |
|      |                       | C2.182       | -10.844   | 0.000              | -4.988             | 5.289     | 4.640              | 5.798              | 5.438              | -0.121             | -7.276             | 3.771              | 2.946              | 5.746  | 5.227  |
|      |                       | C2.182.asinh | -8.922    | 4.898              | 0.000              | 7.509     | 7.348              | 7.865              | 7.748              | -0.843             | -7.470             | 5.944              | 5.382              | 7.652  | 7.347  |
|      |                       | C2.364       | -16.192   | -5.289             | -7.509             | 0.000     | -0.493             | 3.182              | 2.346              | -7.360             | -9.088             | -1.384             | -1.980             | 2.754  | 1.933  |
|      |                       | C2.364.asinh | -15.679   | -6.460             | -7.348             | 0.494     | -4.032             | 2.832              | 3.051              | -6.826             | -12.381            | -0.867             | -1.890             | 2.638  | 2.256  |
|      |                       | C2.728       | -19.205   | -5.798             | -7.865             | -1.382    | -2.832             | 0.000              | -0.361             | -7.785             | -9.465             | -3.086             | -3.453             | 0.706  | -0.052 |
|      |                       | C2.728.asinh | -18.494   | -5.438             | -7.749             | -2.346    | -3.051             | 0.361              | 0.000              | -7.459             | -9.290             | -2.617             | -3.399             | 0.764  | 0.173  |
|      |                       | C3.182       | -8.200    | 5.121              | 0.843              | 7.360     | 6.828              | 7.785              | 7.458              | 0.000              | -4.705             | 7.725              | 6.570              | 8.719  | 8.180  |
|      |                       | C3.182.asinh | -6.352    | 7.276              | 4.740              | 9.088     | 8.890              | 9.465              | 9.290              | 4.706              | 0.000              | 9.666              | 9.085              | 10.318 | 10.172 |
| DK1  | 2019.05.13-2020.05.12 | C3.364       | -14.976   | -3.771             | -5.944             | 1.384     | 0.867              | 3.086              | 2.617              | -7.725             | -9.466             | 0.000              | -1.417             | 4.727  | 3.468  |
|      |                       | C3.364.asinh | -14.213   | -2.948             | 5.382              | 1.980     | 1.890              | 3.453              | 3.399              | -6.570             | -9.085             | 1.417              | 0.000              | 4.684  | 4.793  |
|      |                       | C3.728       | -18.802   | -5.746             | -7.652             | -2.754    | -2.635             | -0.706             | -0.764             | -8.713             | -10.318            | -4.727             | -4.684             | 0.000  | -0.991 |
|      |                       | C4.182       | -18.010   | -5.227             | -7.347             | -1.933    | -2.256             | 0.052              | -0.173             | -8.180             | -10.172            | -3.488             | -4.793             | 0.991  | 0.000  |
|      |                       | C4.182.asinh | -7.515    | 4.934              | 1.408              | 7.151     | 6.728              | 7.612              | 7.355              | 1.321              | -2.799             | 7.307              | 6.413              | 8.359  | 7.942  |
|      |                       | C4.364       | -5.690    | 7.337              | 4.966              | 9.072     | 8.652              | 9.466              | 9.365              | 4.940              | 1.737              | 9.292              | 8.931              | 10.054 | 9.730  |
|      |                       | C4.364.asinh | -14.846   | -4.057             | -6.134             | 0.393     | 0.111              | 2.022              | 1.733              | -7.781             | -9.509             | -1.223             | -1.895             | 2.193  | 1.406  |
|      |                       | C4.728       | -19.188   | -4.497             | -8.316             | -3.913    | -3.684             | -2.319             | -2.117             | -9.373             | -10.917            | -5.870             | -5.728             | -3.264 | 0.000  |
|      |                       | C4.728.asinh | -18.057   | 5.479              | 7.562              | -2.324    | -2.620             | -0.559             | -0.794             | -8.353             | -10.333            | -3.780             | -5.024             | -0.082 | -1.375 |

Figure 38: Diebold-Mariano Test for consumption forecasts (DK1)

| Area | Dates                 | Model 1      | C1<br>728 | C2<br>182<br>asinh | C2<br>364<br>asinh | C2<br>728 | C2<br>728<br>asinh | C3<br>182<br>asinh | C3<br>364<br>asinh | C3<br>728<br>asinh | C4<br>182<br>asinh | C4<br>364<br>asinh | C4<br>728<br>asinh |        |        |
|------|-----------------------|--------------|-----------|--------------------|--------------------|-----------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------|--------|
|      |                       | C1.728       | 0.000     | 13.508             | 10.634             | 19.605    | 18.935             | 23.068             | 22.014             | 10.158             | 7.425              | 18.074             | 17.003             | 22.679 | 21.409 |
|      |                       | C2.182       | -13.508   | 0.000              | -7.002             | 5.778     | 4.987              | 6.492              | 5.775              | -5.584             | -9.920             | 4.094              | 2.938              | 6.835  | 5.630  |
|      |                       | C2.182.asinh | -10.634   | 7.002              | 0.000              | 8.966     | 8.671              | 9.474              | 9.051              | -0.405             | -6.082             | 7.220              | 6.352              | 9.420  | 8.690  |
|      |                       | C2.364       | -19.605   | -5.778             | -4.966             | 0.000     | -0.951             | 3.289              | 1.790              | -8.703             | -11.329            | -1.793             | -2.845             | 3.220  | 1.611  |
|      |                       | C2.364.asinh | -18.963   | -4.967             | -6.671             | 0.951     | 0.000              | 3.262              | 2.703              | -0.005             | -10.994            | -0.971             | -2.578             | 3.291  | 2.151  |
|      |                       | C2.728       | -23.088   | -6.492             | -9.474             | -3.289    | -3.262             | 0.000              | -1.595             | -9.236             | -11.778            | -3.498             | -4.283             | 1.196  | -0.608 |
|      |                       | C2.728.asinh | -22.014   | -5.775             | -7.051             | -1.790    | -2.703             | 1.995              | 0.000              | -8.599             | -11.339            | -2.535             | -3.760             | 1.860  | 0.322  |
|      |                       | C3.182       | -10.158   | 6.584              | 0.465              | 8.703     | 8.05               | 9.230              | 8.890              | 0.000              | -6.842             | 8.919              | 7.419              | 10.381 | 9.390  |
|      |                       | C3.182.asinh | -7.425    | 9.920              | 0.828              | 11.323    | 10.994             | 11.778             | 11.339             | 6.942              | 0.000              | 11.610             | 10.972             | 12.836 | 12.313 |
| DK1  | 2019.01.01-2020.05.12 | C3.364       | -10.074   | -4.094             | -7.220             | 1.793     | 0.971              | 3.498              | 2.535              | -8.919             | -11.610            | 0.000              | -2.327             | 5.593  | 3.451  |
|      |                       | C3.364.asinh | -17.003   | -2.938             | -4.352             | 2.845     | 2.578              | 4.283              | 3.760              | -7.419             | -10.972            | 2.327              | 0.000              | 5.974  | 5.307  |
|      |                       | C3.728       | -22.679   | -6.835             | -4.929             | 3.226     | -3.291             | -1.196             | -1.860             | -10.381            | -12.836            | -5.593             | -5.974             | 0.000  | -2.548 |
|      |                       | C4.182       | -21.409   | -5.630             | -4.896             | -1.611    | -2.181             | 0.608              | -0.322             | -9.399             | -12.813            | -3.451             | -5.307             | 2.548  | 0.000  |
|      |                       | C4.182.asinh | -9.340    | 6.399              | 1.254              | 8.614     | 8.032              | 9.153              | 8.603              | 1.721              | -4.389             | 8.666              | 7.433              | 10.122 | 9.281  |
|      |                       | C4.364       | -17.640   | -3.956             | -7.024             | 1.393     | 0.774              | 2.970              | 2.190              | -8.526             | -11.252            | -0.134             | -1.798             | 4.376  | 2.832  |
|      |                       | C4.364.asinh | -16.441   | -2.590             | -5.936             | 2.815     | 2.531              | 4.127              | 3.637              | -6.866             | -10.367            | 2.155              | 0.668              | 5.454  | 4.771  |
|      |                       | C4.728       | -22.895   | -7.217             | -9.919             | -4.118    | -4.106             | -2.457             | -2.872             | -10.886            | -13.276            | -8.381             | -6.710             | -2.738 | -3.730 |
|      |                       | C4.728.asinh | -21.399   | -5.818             | -8.843             | -1.949    | -2.456             | 0.030              | -0.833             | -9.494             | -12.404            | -3.687             | -5.425             | 1.256  | -1.182 |

Figure 39: Diebold-Mariano Test for consumption forecasts (DK1)

| Area | Dates                 | Model 1      | C1<br>728 | C2<br>182 | C2<br>364 | C2<br>728 | C2<br>asinh | C3<br>728 | C2<br>182 | C2<br>364 | C3<br>728 | C2<br>asinh | C4<br>728 | C4<br>182 | C4<br>364 | C4<br>728 | C4<br>asinh |        |        |        |        |
|------|-----------------------|--------------|-----------|-----------|-----------|-----------|-------------|-----------|-----------|-----------|-----------|-------------|-----------|-----------|-----------|-----------|-------------|--------|--------|--------|--------|
| DK1  | 2020.01.01-2020.05.12 | C1.728       | 0.000     | 6.263     | 4.549     | 8.080     | 8.317       | 9.948     | 9.695     | 4.805     | 3.425     | 6.994       | 6.954     | 9.300     | 9.021     | 4.644     | 3.340       | 7.109  | 6.928  | 9.557  | 8.999  |
|      |                       | C2.182       | -6.263    | 0.000     | -6.418    | 0.883     | 1.444       | 1.493     | 1.778     | -3.500    | -5.233    | -0.378      | 1.142     | 1.166     | -2.444    | -4.410    | 0.240       | 0.153  | 1.659  | 1.271  |        |
|      |                       | C2.182.asinh | -4.549    | 4.618     | 0.000     | 3.759     | 4.271       | 3.949     | 4.210     | 0.780     | -2.136    | 2.293       | 2.411     | 3.454     | 3.455     | 0.773     | -1.634      | 2.710  | 2.585  | 3.892  | 3.506  |
|      |                       | C2.364       | -8.080    | -0.883    | -3.759    | 0.000     | 1.682       | 1.935     | 2.239     | -2.781    | -4.492    | -1.949      | -1.283    | 0.818     | 0.837     | -2.307    | -3.965      | -0.684 | -0.701 | 1.598  | 0.961  |
|      |                       | C2.364.asinh | -8.317    | -1.444    | -4.271    | -1.682    | 0.000       | 0.347     | 1.329     | -3.111    | -4.840    | -2.497      | -2.353    | -0.187    | -0.057    | -2.650    | -4.283      | -1.352 | -1.502 | 0.584  | 0.140  |
|      |                       | C2.728       | 9.948     | -1.493    | -3.949    | -1.935    | -0.347      | 0.000     | 1.216     | -3.085    | -4.666    | -2.741      | -2.169    | -0.684    | -0.386    | -2.666    | -4.204      | -1.541 | -1.522 | 0.467  | -0.116 |
|      |                       | C2.728.asinh | 9.695     | -1.778    | -4.210    | -2.236    | -1.329      | -1.216    | 0.000     | -3.259    | -4.635    | -2.899      | -2.693    | -1.230    | -1.198    | -2.658    | -4.366      | -1.841 | -1.971 | -0.241 | -0.786 |
|      |                       | C3.182       | -4.805    | 3.500     | -0.780    | 2.781     | 3.111       | 3.085     | 3.259     | 0.000     | -3.820    | 1.967       | 1.977     | 3.078     | 3.009     | 0.191     | -2.739      | 2.440  | 2.210  | 3.547  | 3.068  |
|      |                       | C3.182.asinh | 3.425     | 5.233     | 2.136     | 4.492     | 4.840       | 4.668     | 4.835     | 3.820     | 0.000     | 3.992       | 4.134     | 4.761     | 4.798     | 2.891     | 0.163       | 4.312  | 4.223  | 5.168  | 4.818  |
|      |                       | C3.364       | 6.994     | 0.378     | -2.293    | 1.949     | 2.497       | 2.741     | 2.899     | -1.967    | -3.992    | 0.000       | 0.508     | 3.163     | 2.706     | -1.523    | -3.409      | 1.292  | 0.870  | 3.787  | 2.669  |
|      |                       | C3.364.asinh | -6.964    | 0.143     | -2.411    | 1.283     | 2.353       | 2.169     | 2.693     | -1.977    | -4.134    | -0.508      | 0.000     | 2.233     | 2.681     | -1.597    | -3.542      | 0.634  | 0.720  | 2.911  | 2.647  |
|      |                       | C3.728       | 9.300     | -1.142    | -3.452    | -0.812    | 0.187       | 0.684     | 1.230     | -3.076    | -4.761    | -1.363      | -2.223    | 0.000     | 0.256     | -2.589    | -4.227      | -1.415 | -1.376 | 1.826  | 0.494  |
|      |                       | C3.728.asinh | 9.021     | -1.166    | -3.455    | -0.837    | 0.057       | 0.386     | 1.198     | -3.009    | -4.798    | -2.706      | -2.681    | -0.256    | 0.000     | -2.572    | -4.267      | -1.379 | -1.625 | 1.017  | 0.470  |
|      |                       | C4.182       | -6.444    | 2.444     | -0.773    | 2.307     | 2.650       | 2.666     | 2.688     | -0.191    | -2.891    | 1.523       | 1.597     | 2.589     | 2.572     | 0.000     | -3.668      | 2.413  | 4.183  | 4.915  | 4.552  |
|      |                       | C4.364       | -7.109    | -2.040    | -2.710    | 0.684     | 1.352       | 1.541     | 1.841     | -2.440    | -4.312    | -1.292      | -0.634    | 1.415     | 1.379     | -2.413    | -4.315      | 0.000  | -0.170 | 2.763  | 1.733  |
|      |                       | C4.364.asinh | -6.928    | -0.153    | -2.585    | 0.701     | 1.520       | 1.522     | 1.971     | -2.171    | -4.223    | -0.870      | -0.720    | 1.376     | 1.629     | -2.079    | -4.183      | 0.170  | 0.000  | 2.472  | 2.152  |
|      |                       | C4.728       | 9.057     | -1.659    | -3.892    | -1.598    | -0.584      | -0.467    | 0.241     | -3.547    | -5.168    | -3.787      | -2.911    | -1.826    | -1.017    | -3.259    | -4.915      | -2.763 | -2.472 | 0.000  | 0.874  |
|      |                       | C4.728.asinh | -8.969    | -1.271    | -3.506    | -0.961    | -0.140      | 0.116     | 0.786     | -3.068    | -4.818    | -2.669      | -4.094    | -0.470    | -0.273    | -4.552    | -4.173      | -2.152 | 0.874  | 0.000  |        |

Figure 40: Diebold-Mariano Test for consumption forecasts (DK1)

| Area | Dates                 | Model 1      | C2<br>182 | C2<br>364 | C2<br>728 | C3<br>182 | C3<br>364 | C3<br>728 | C3<br>hp | C3<br>182 | C3<br>364 | C3<br>728 | C3<br>asinh | C4<br>182 | C4<br>364 | C4<br>728 | C4<br>hp |         |        |        |        |        |
|------|-----------------------|--------------|-----------|-----------|-----------|-----------|-----------|-----------|----------|-----------|-----------|-----------|-------------|-----------|-----------|-----------|----------|---------|--------|--------|--------|--------|
| DK2  | 2019.01.01-2019.12.31 | C2.182       | 0.000     | 9.770     | 10.392    | 3.804     | -4.708    | 4.113     | 8.435    | 5.173     | 7.792     | 11.176    | 9.285       | 5.608     | 2.334     | 2.573     | 6.632    | 3.272   | 5.827  | 9.359  | 7.281  | 4.219  |
|      |                       | C2.364       | -9.770    | 0.000     | 3.696     | -3.330    | -9.940    | -3.062    | 2.202    | -1.027    | 1.548     | 5.189     | 3.081       | -0.839    | -4.389    | -4.180    | 0.272    | -2.978  | -0.562 | 3.107  | 0.885  | -2.288 |
|      |                       | C2.728       | -10.392   | 3.695     | 0.000     | 4.528     | 10.581    | -2.491    | 0.385    | -2.441    | -0.168    | 3.591     | 1.304       | -2.814    | -5.402    | -5.310    | -1.318   | -4.226  | -2.000 | 1.346  | 0.914  | -4.347 |
|      |                       | C3.182       | -3.804    | 3.330     | 4.528     | 0.000     | -13.661   | 2.727     | 7.750    | 3.121     | 6.457     | 9.240     | 7.332       | 2.734     | 5.152     | -3.856    | 5.103    | 0.472   | 3.756  | 7.188  | 4.961  | 1.266  |
|      |                       | C3.364       | 4.708     | 9.840     | 10.394    | 0.000     | 13.991    | 14.639    | 11.833   | 13.568    | 13.451    | 14.446    | 9.673       | 11.157    | 11.388    | 12.675    | 9.377    | 11.469  | 13.752 | 12.396 | 8.360  |        |
|      |                       | C3.364.asinh | -5.113    | -2.062    | 4.249     | -2.772    | -13.991   | 0.000     | 7.311    | 2.754     | 6.265     | 9.927     | 7.029       | 2.585     | -3.877    | -5.359    | 4.695    | 3.878   | 3.488  | 4.878  | 4.469  | 1.017  |
|      |                       | C3.728       | -7.792    | -1.548    | 0.166     | -6.457    | -13.985   | -6.265    | 1.832    | -5.098    | 0.000     | 4.999     | 2.077       | -3.820    | -7.713    | -7.616    | -2.934   | -7.976  | -7.330 | 2.04   | -0.996 | -5.561 |
|      |                       | C4.182       | -11.176   | 5.189     | -3.591    | -9.243    | -15.451   | -9.827    | -4.343   | -8.046    | -4.990    | 0.000     | -4.788      | -9.956    | -10.264   | -10.002   | -6.868   | -10.270 | -7.788 | -7.04  | 4.855  | 11.857 |
|      |                       | C4.182.asinh | -9.295    | 3.081     | 1.394     | -7.332    | -14.682   | -7.029    | -1.327   | -6.978    | -2.207    | 4.789     | 0.000       | -4.245    | -8.434    | -8.202    | 4.003    | -9.423  | -5.149 | -0.216 | -7.669 | -4.281 |
|      |                       | C4.364       | 5.698     | 0.839     | 2.814     | -2.744    | -9.673    | -2.355    | 3.715    | -0.287    | 3.820     | 9.956     | 6.245       | 0.000     | -3.870    | -3.767    | 1.324    | -2.633  | 0.398  | 6.307  | 2.634  | -6.400 |
|      |                       | C4.364.asinh | -5.117    | -2.027    | 2.441     | -3.112    | -11.833   | 2.754     | 3.739    | 0.000     | 5.096     | 8.046     | 6.979       | 0.287     | -4.511    | -4.224    | -2.688   | -6.594  | 0.909  | 5.391  | 3.170  | -1.414 |
|      |                       | C4.728       | -11.176   | -5.189    | -3.591    | -9.243    | -15.451   | -9.827    | -4.343   | -8.046    | -4.990    | 0.000     | -4.788      | -9.956    | -10.264   | -10.002   | -6.868   | -10.270 | -7.788 | -7.04  | 4.855  | 11.857 |
|      |                       | C4.728.asinh | -9.295    | -3.107    | -1.348    | -7.186    | -13.752   | -6.878    | -1.194   | -5.391    | -2.041    | 7.044     | 0.216       | -3.607    | -8.318    | -8.079    | -4.227   | -8.307  | -5.318 | 0.000  | -5.681 | -9.716 |
|      |                       | C4.728.hp    | 7.281     | 0.885     | 0.914     | 4.951     | -12.396   | -4.649    | 1.934    | -3.170    | 0.998     | 8.556     | 7.669       | 2.634     | -6.164    | -5.933    | -0.915   | -6.669  | -2.163 | 5.683  | 0.000  | 5.377  |
|      |                       | C4.728.hp    | -4.219    | 2.288     | 4.347     | -1.266    | -8.360    | -1.017    | 5.473    | 1.414     | 5.951     | 11.857    | 8.281       | 4.600     | -2.445    | -2.296    | 3.176    | -1.020  | 2.687  | 9.716  | 5.377  |        |

Figure 41: Diebold-Mariano Test for consumption forecasts (DK2)

| Area | Dates                 | Model 1      | C2<br>182 | C2<br>364 | C2<br>728 | C3<br>182 | C3<br>364 | C3<br>728 | C3<br>hp | C3<br>182 | C3<br>364 | C3<br>728 | C3<br>asinh | C4<br>182 | C4<br>364 | C4<br>728 | C4<br>hp |        |        |       |        |        |        |
|------|-----------------------|--------------|-----------|-----------|-----------|-----------|-----------|-----------|----------|-----------|-----------|-----------|-------------|-----------|-----------|-----------|----------|--------|--------|-------|--------|--------|--------|
| DK2  | 2019.05.13-2020.05.12 | C2.182       | 0.000     | 2.117     | 2.086     | 5.109     | -2.687    | 5.517     | 3.903    | 2.449     | 3.339     | 3.512     | 2.586       | 0.605     | 4.065     | 4.163     | 2.191    | 4.077  | 2.752  | 1.496 | -0.024 |        |        |
|      |                       | C2.364       | -2.117    | 0.000     | 2.407     | 2.433     | -3.613    | 2.743     | 2.918    | 1.161     | 3.211     | 2.397     | 1.205       | -0.937    | 1.683     | 1.919     | 2.789    | 0.852  | 2.995  | 1.501 | 0.466  | -1.611 |        |
|      |                       | C2.728       | -2.086    | -0.407    | 0.000     | 2.124     | -3.578    | 2.421     | 2.416    | 0.678     | 2.824     | 2.379     | 1.171       | -1.176    | 1.425     | 1.652     | 2.319    | 0.601  | 2.553  | 1.402 | -0.148 | -1.883 |        |
|      |                       | C3.182       | -5.109    | -2.433    | -2.124    | 0.000     | -12.815   | 3.063     | -1.033   | -1.750    | 0.461     | -0.450    | -1.412      | -3.428    | -3.436    | -0.121    | -2.059   | 0.167  | 1.260  | 2.607 | -0.466 |        |        |
|      |                       | C3.182.asinh | 2.867     | 3.613     | 3.578     | 11.815    | -12.312   | 0.000     | 0.570    | -2.133    | 0.228     | -0.828    | -1.774      | -3.885    | -4.532    | -3.824    | -0.640   | -2.427 | -0.263 | 1.621 | -2.949 | -4.530 |        |
|      |                       | C3.364       | -3.903    | -2.918    | -2.416    | 0.133     | -8.854    | 0.570     | 0.000    | -4.283    | 1.485     | -0.586    | -2.170      | -4.426    | -4.800    | -0.459    | -0.352   | -4.554 | 0.657  | 1.932 | 4.007  | -5.236 |        |
|      |                       | C3.364.asinh | -2.449    | -1.161    | -0.878    | 1.170     | -5.378    | 2.133     | 4.283    | 0.000     | 4.294     | 3.704     | 1.772       | -0.320    | -2.502    | 0.841     | 1.138    | 3.547  | -1.466 | 3.459 | 0.491  | -1.765 | -3.313 |
|      |                       | C3.728       | -4.339    | -3.311    | -2.824    | -0.461    | -7.263    | -0.928    | -1.485   | -4.294    | 0.000     | -1.313    | -2.756      | -6.511    | -1.351    | -1.039    | -1.489   | -4.615 | -1.305 | 2.477 | -4.431 | -7.463 |        |
|      |                       | C3.728.asinh | -5.312    | -2.397    | -2.379    | 0.450     | -5.975    | 0.828     |          |           |           |           |             |           |           |           |          |        |        |       |        |        |        |

| Area | Dates                 | Model 1      | C2<br>182 | C2<br>364 | C2<br>728 | C3<br>182 | C3<br>364 | C3<br>hp | C3<br>asinh | C3<br>728 | C3<br>182 | C3<br>364 | C3<br>hp | C3<br>asinh | C3<br>728 | C3<br>182 | C3<br>364 | C3<br>hp | C3<br>asinh | C3<br>728 | C4<br>182 | C4<br>364 | C4<br>hp | C4<br>asinh | C4<br>728 | C4<br>182 | C4<br>364 | C4<br>hp | C4<br>asinh | C4<br>728 |
|------|-----------------------|--------------|-----------|-----------|-----------|-----------|-----------|----------|-------------|-----------|-----------|-----------|----------|-------------|-----------|-----------|-----------|----------|-------------|-----------|-----------|-----------|----------|-------------|-----------|-----------|-----------|----------|-------------|-----------|
|      |                       |              | 182       | 364       | 728       | 182       | 364       | 728      | 182         | 364       | 728       | 182       | 364      | 728         | 182       | 364       | 728       | 182      | 364         | 728       | 182       | 364       | 728      | 182         | 364       | 728       | 182       | 364      | 728         |           |
| DK2  | 2018.01.01-2020.05.12 | C2.182       | 0.000     | 6.174     | 4.472     | 4.188     | -5.821    | 4.689    | 6.054       | 2.757     | 6.139     | 5.954     | 4.302    | 1.998       | 2.766     | 3.179     | 4.671     | 1.204    | 4.548       | 4.474     | 2.526     | 0.725     |          |             |           |           |           |          |             |           |
|      |                       | C2.364       | -6.174    | 0.000     | -1.767    | -0.922    | -8.712    | -0.499   | 2.067       | -1.493    | 2.172     | 1.93      | 0.106    | -2.399      | -1.941    | -1.588    | 0.504     | -3.163   | 0.38        | 0.230     | -1.883    | -3.762    |          |             |           |           |           |          |             |           |
|      |                       | C2.728       | -4.472    | 1.767     | 0.000     | -0.192    | -7.665    | 0.199    | 2.651       | -0.660    | 2.76      | 3.045     | 0.980    | -1.737      | -1.161    | -0.833    | 1.218     | -2.238   | 1.10        | 1.162     | -1.127    | -3.200    |          |             |           |           |           |          |             |           |
|      |                       | C3.182       | -1.818    | 0.822     | 0.198     | 0.000     | [15.861]  | 4.068    | 3.831       | -0.568    | 3.640     | 2.917     | 1.161    | -1.332      | -4.776    | -2.874    | 1.813     | -2.538   | 1.615       | 1.292     | -0.849    | -2.678    |          |             |           |           |           |          |             |           |
|      |                       | C3.182.asinh | 5.621     | 8.712     | 7.665     | [15.961]  | 0.000     | [18.529] | 12.576      | 9.398     | 12.434    | 11.271    | 10.023   | 7.061       | [13.437]  | 13.881    | 11.099    | 7.511    | [10.773]    | 9.821     | 8.148     | 5.908     |          |             |           |           |           |          |             |           |
|      |                       | C3.182.hp    | 4.889     | 0.499     | 1.019     | -4.088    | [18.529]  | 0.000    | 3.012       | -1.084    | 3.150     | 2.409     | 0.876    | -1.822      | -0.889    | -5.050    | 1.238     | -3.024   | 1.098       | 0.783     | 1.318     | -3.201    |          |             |           |           |           |          |             |           |
|      |                       | C3.364       | 6.054     | 2.067     | -2.651    | -3.831    | -12.576   | -0.312   | 0.000       | -8.471    | 0.519     | 0.311     | -3.067   | -5.958      | -4.976    | -4.352    | -5.361    | [10.573] | 3.756       | -2.942    | 5.911     | -7.305    |          |             |           |           |           |          |             |           |
|      |                       | C3.364.asinh | 2.757     | 1.491     | 0.660     | 0.566     | 9.395     | 1.084    | 0.471       | 0.000     | 3.786     | 4.850     | 2.900    | -1.093      | -0.746    | -0.310    | 4.218     | -5.999   | 3.511       | 2.487     | -0.560    | -2.777    |          |             |           |           |           |          |             |           |
|      |                       | C3.364.hp    | 6.139     | 2.117     | -2.768    | -3.640    | -12.434   | -3.150   | -0.519      | -7.388    | 0.000     | 0.550     | 3.143    | -7.453      | -4.846    | -4.473    | -3.875    | [0.577]  | 6.387       | -2.947    | 5.936     | -9.439    |          |             |           |           |           |          |             |           |
|      |                       | C3.728       | 5.954     | 1.931     | -3.044    | -2.917    | -11.271   | -2.409   | 0.311       | -4.859    | 0.550     | 0.492     | -7.510   | -4.026      | -3.600    | -2.100    | -6.987    | -2.08    | 6.444       | 8.603     | -9.502    |           |          |             |           |           |           |          |             |           |
|      |                       | C3.728.asinh | -4.302    | -0.104    | -0.984    | -1.161    | -10.023   | -0.676   | 3.067       | -2.900    | 3.143     | 4.942     | 0.000    | -4.188      | -2.310    | -1.906    | 0.594     | -5.440   | 0.418       | 0.231     | -7.602    | -6.266    |          |             |           |           |           |          |             |           |
|      |                       | C3.728.hp    | 1.960     | 2.399     | 1.737     | 1.332     | -7.061    | 1.822    | 5.598       | 1.093     | 7.463     | 7.510     | 4.188    | 0.000       | 0.223     | 0.600     | 3.582     | -0.995   | 4.322       | 4.471     | 0.900     | -6.357    |          |             |           |           |           |          |             |           |
|      |                       | C4.182       | 2.766     | 1.941     | 1.161     | 4.776     | [13.437]  | 6.089    | 4.876       | 0.746     | 4.846     | 4.026     | 2.310    | -0.223      | 0.000     | 3.462     | 3.237     | -1.244   | 2.978       | 2.447     | 0.340     | 1.559     |          |             |           |           |           |          |             |           |
|      |                       | C4.182.asinh | -3.179    | 1.586     | 0.833     | 2.874     | -13.881   | 5.050    | 4.352       | 0.310     | 4.743     | 3.600     | 1.906    | -0.600      | -3.452    | 0.000     | 2.725     | -1.666   | 2.567       | 2.035     | -0.651    | -1.972    |          |             |           |           |           |          |             |           |
|      |                       | C4.182.hp    | -3.179    | 1.586     | 0.833     | 2.874     | -13.881   | 5.050    | 4.352       | 0.310     | 4.743     | 3.600     | 1.906    | -0.600      | -3.452    | 0.000     | 2.725     | -1.666   | 2.567       | 2.035     | -0.651    | -1.972    |          |             |           |           |           |          |             |           |
|      |                       | C4.364       | -4.671    | 0.504     | 1.216     | -1.813    | -11.099   | -1.235   | 5.381       | -4.218    | 3.875     | 2.100     | -0.594   | -3.582      | -3.237    | -2.725    | 0.000     | [0.276]  | 0.317       | -0.458    | 3.692     | -5.439    |          |             |           |           |           |          |             |           |
|      |                       | C4.364.asinh | -1.201    | 3.163     | 2.23      | 2.536     | -7.511    | 3.024    | 10.573      | 5.998     | 9.577     | 6.987     | 5.440    | 0.995       | 1.244     | 1.666     | 9.278     | 0.000    | 7.563       | 5.023     | 2.423     | -0.674    |          |             |           |           |           |          |             |           |
|      |                       | C4.364.hp    | -4.588    | 0.388     | 1.109     | -1.615    | -10.773   | -1.098   | 3.756       | -3.511    | 6.837     | 2.08      | -0.418   | -4.322      | -2.978    | -2.567    | 0.317     | -7.568   | 0.000       | -0.284    | -3.363    | -6.652    |          |             |           |           |           |          |             |           |
|      |                       | C4.728       | -4.474    | 0.230     | 1.166     | -1.282    | -9.821    | -0.793   | 2.942       | -2.487    | 2.947     | 6.467     | -0.281   | -4.471      | -2.447    | -2.035    | 0.458     | -5.023   | 0.261       | 0.000     | 6.137     | -7.493    |          |             |           |           |           |          |             |           |
|      |                       | C4.728.asinh | 2.526     | 1.893     | 1.127     | 0.849     | -8.148    | 1.318    | 5.991       | 0.560     | 5.936     | 8.603     | 7.602    | -0.900      | -0.340    | 0.051     | 3.682     | -2.423   | 3.363       | 6.137     | 0.000     | -3.387    |          |             |           |           |           |          |             |           |
|      |                       | C4.728.hp    | 0.725     | 3.762     | 3.200     | 2.678     | -5.808    | 3.201    | 7.305       | 2.777     | 9.439     | 9.502     | 6.266    | 0.357       | 1.559     | 1.972     | 5.439     | 0.674    | 6.652       | 7.493     | 3.387     | 0.000     |          |             |           |           |           |          |             |           |

Figure 43: Diebold-Mariano Test for consumption forecasts (DK2)

| Area | Dates                 | Model 1      | C2<br>182 | C2<br>364 | C2<br>728 | C3<br>182 | C3<br>364 | C3<br>hp | C3<br>asinh | C3<br>728 | C3<br>182 | C3<br>364 | C3<br>hp | C3<br>asinh | C3<br>728 | C3<br>182 | C3<br>364 | C3<br>hp | C3<br>asinh | C3<br>728 | C4<br>182 | C4<br>364 | C4<br>hp | C4<br>asinh | C4<br>728 | C4<br>182 | C4<br>364 | C4<br>hp | C4<br>asinh | C4<br>728 |
|------|-----------------------|--------------|-----------|-----------|-----------|-----------|-----------|----------|-------------|-----------|-----------|-----------|----------|-------------|-----------|-----------|-----------|----------|-------------|-----------|-----------|-----------|----------|-------------|-----------|-----------|-----------|----------|-------------|-----------|
|      |                       |              | 182       | 364       | 728       | 182       | 364       | 728      | 182         | 364       | 728       | 182       | 364      | 728         | 182       | 364       | 728       | 182      | 364         | 728       | 182       | 364       | 728      | 182         | 364       | 728       | 182       | 364      | 728         |           |
| DK2  | 2020.01.01-2020.05.12 | C2.182       | 0.000     | -3.683    | -8.047    | 1.755     | -3.697    | 2.299    | -2.740      | -3.795    | -1.515    | -6.175    | -6.385   | -5.377      | 1.574     | 2.052     | -2.435    | -3.637   | -1.278      | -6.187    | -6.600    | -5.576    |          |             |           |           |           |          |             |           |
|      |                       | C2.364       | 3.683     | 0.000     | [10.963]  | 3.988     | -0.255    | 4.289    | 0.226       | -1.300    | 1.752     | -4.293    | -4.663   | -3.179      | 3.858     | 4.130     | 0.586     | -1.101   | 1.990       | -4.375    | -4.974    | -3.460    |          |             |           |           |           |          |             |           |
|      |                       | C2.728       | 8.047     | [10.983]  | 0.000     | 7.515     | 3.126     | 7.171    | 1.491       | 3.316     | 6.099     | 0.252     | -0.258   | 0.952       | 7.372     | 7.955     | 5.248     | 3.454    | 6.277       | 0.108     | -0.660    | 0.633     |          |             |           |           |           |          |             |           |
|      |                       | C3.182       | -1.755    | -3.988    | -7.515    | 0.000     | -8.429    | 1.131    | -3.899      | -5.432    | -2.989    | -7.925    | -8.060   | -6.638      | -0.364    | 1.156     | -4.027    | -5.254   | -2.712      | -7.919    | -8.260    | -7.030    |          |             |           |           |           |          |             |           |
|      |                       | C3.182.asinh | 3.697     | 0.255     | -3.126    | 8.429     | 0.000     | 0.046    | 0.453       | 0.724     | 1.639     | -3.195    | -3.543   | -2.467      | 7.776     | 8.313     | 0.724     | -0.583   | 1.845       | -3.265    | -3.813    | -2.703    |          |             |           |           |           |          |             |           |
|      |                       | C3.182.hp    | -2.299    | -4.289    | -7.717    | 3.133     | 9.040     | 0.000    | -4.696      | 5.725     | -3.421    | -8.122    | -8.281   | -7.334      | -1.936    | -0.540    | -4.345    | -5.554   | -3.144      | -8.121    | -8.479    | -7.524    |          |             |           |           |           |          |             |           |
|      |                       | C3.364       | 2.740     | -0.226    | -4.981    | 4.389     | 0.453     | 4.696    | 0.000       | -4.310    | 4.260     | 8.698     | 8.766    | 4.871       | 4.223     | 4.499     | 1.590     | 3.315    | 4.323       | 8.604     | 9.005     | 5.238     |          |             |           |           |           |          |             |           |
|      |                       | C3.364.asinh | 3.795     | 1.300     | -3.316    | 5.432     | 0.724     | 3.725    | 0.000       | 3.141     | 6.638     | 5.130     | -6.843   | -2.976      | 5.260     | 5.523     | 4.480     | 0.869    | 6.556       | 5.182     | -7.132    | -3.352    |          |             |           |           |           |          |             |           |
|      |                       | C3.364.hp    | 1.515     | -1.752    | -0.050    | 2.969     | 1.639     | 3.421    | -4.260      | -6.638    | 0.000     | 9.942     | -9.839   | -8.601      | 2.656     | 3.245     | -2.615    | -5.749   | 1.262       | -9.388    | -10.111   | -9.867    |          |             |           |           |           |          |             |           |
|      |                       | C3.728       | 6.175     | 4.293     | -0.256    | 7.922     | 3.195     | 3.122    | 8.609       | 5.130     | 9.342     | 0.000     | -1.573   | 1.300       | 7.757     | 7.935     | 8.801     | 5.233    | 9.426       | 0.613     | -2.324    | 0.712     |          |             |           |           |           |          |             |           |
|      |                       | C3.728.asinh | 6.385     | 4.663     | 0.256     | 8.060     | 3.543     | 8.281    | 8.766       | 6.843     | 9.839     | 1.573     | 0.000    | 2.032       | 7.883     | 8.083     | 8.838     | 6.795    | 9.866       | 0.960     | -1.780    | 1.438     |          |             |           |           |           |          |             |           |
|      |                       | C3.728.hp    | 5.377     | 3.179     | -0.955    | 6.832     | 2.467     | 7.334    | 4.871       | 2.976     | 8.601     | -1.300    | -2.032   | 0.000       | 6.715     | 7.172     | 5.190     | 3.139    | 8.789       | -1.451    | -2.543    | -1.541    |          |             |           |           |           |          |             |           |
|      |                       | C4.182       | -1.574    | -3.858    | -7.372    | 0.364     | -7.776    | 1.936</  |             |           |           |           |          |             |           |           |           |          |             |           |           |           |          |             |           |           |           |          |             |           |

### 7.1.2 Wind power forecasts

| Area | Dates                 | Model 1         | W2_182_asinh-hp | W2_182_hp | W2_244_asinh-hp | W2_244_hp | W2_364_asinh-hp | W2_364_hp | W2_728_asinh-hp | W2_728_hp | W3_182_asinh-hp | W3_182_hp | W3_244_asinh-hp | W3_244_hp | W3_364_asinh-hp | W3_364_hp | W3_728_asinh-hp | W3_728_hp | W4_182_asinh-hp | W4_182_hp | W4_244_asinh-hp | W4_244_hp | W4_364_asinh-hp | W4_364_hp | W4_728_asinh-hp | W4_728_hp |
|------|-----------------------|-----------------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|
| DK1  | 2019-01-01-2019-12-31 | W2.182.asinh-hp | 0.000           | -2.90     | 6.895           | 5.172     | -10.545         | -9.436    | -6.888          | -6.731    | 3.782           | 2.527     | -11.187         | -10.043   | -6.051          | -5.312    | 2.312           | 1.551     | -12.439         | -10.659   |                 |           |                 |           |                 |           |
|      |                       | W2.182.hp       | 2.900           | 0.000     | 8.523           | 7.683     | -9.502          | -8.651    | -3.904          | -6.179    | 5.250           | 4.362     | -10.208         | -9.308    | -3.797          | -4.379    | 3.741           | 2.273     | -11.372         | -9.910    |                 |           |                 |           |                 |           |
|      |                       | W2.364.asinh-hp | -6.895          | -8.523    | 0.000           | -3.204    | -18.413         | -17.171   | -9.724          | -10.639   | -4.643          | -5.976    | -18.895         | -17.658   | -8.890          | -9.180    | -6.791          | -7.400    | -20.128         | -18.318   |                 |           |                 |           |                 |           |
|      |                       | W2.364.hp       | -5.172          | -7.683    | 3.204           | 0.000     | -18.492         | -16.121   | -8.269          | -9.913    | -1.737          | -5.074    | -17.949         | -16.639   | -7.668          | -8.417    | -3.903          | -6.661    | -18.172         | -17.261   |                 |           |                 |           |                 |           |
|      |                       | W2.728.asinh-hp | 10.545          | 9.502     | 18.413          | 16.492    | 0.000           | 5.493     | 6.969           | 6.881     | 15.624          | 14.129    | -3.950          | 1.075     | 8.072           | 6.314     | 14.091          | 13.182    | -5.292          | 0.261     |                 |           |                 |           |                 |           |
|      |                       | W2.728.hp       | 9.436           | 8.601     | 17.171          | 16.121    | -5.493          | 0.000     | 5.906           | 5.757     | 14.364          | 13.558    | -6.613          | -3.670    | 5.097           | 5.454     | 12.820          | 12.504    | -7.511          | -3.500    |                 |           |                 |           |                 |           |
|      |                       | W3.182.asinh-hp | 6.888           | 3.904     | 9.724           | 8.269     | -6.869          | -5.006    | 0.000           | 8.392     | 6.774           | -8.083    | -6.857          | -0.088    | -0.246          | 7.023     | 5.871           | -9.215    | -7.341          |           |                 |           |                 |           |                 |           |
|      |                       | W3.182.hp       | 6.731           | 6.179     | 10.639          | 9.913     | -6.861          | -5.157    | 1.026           | 0.000     | 9.182           | 8.453     | -7.764          | -6.749    | 0.107           | 0.757     | 7.688           | 7.394     | -8.861          | -7.255    |                 |           |                 |           |                 |           |
|      |                       | W3.364.asinh-hp | -3.789          | -5.250    | 4.643           | 1.737     | -15.045         | -14.384   | -8.392          | -9.182    | 0.000           | -2.917    | -17.462         | -15.980   | -7.493          | -7.654    | -5.555          | -4.955    | -15.750         | -16.623   |                 |           |                 |           |                 |           |
|      |                       | W3.364.hp       | -2.527          | -4.362    | 5.976           | 5.074     | -14.129         | -13.559   | -6.774          | -8.453    | 2.917           | 0.000     | -15.652         | -15.101   | -6.211          | -6.875    | -6.662          | -4.612    | -15.816         | -15.708   |                 |           |                 |           |                 |           |
|      |                       | W3.728.asinh-hp | 11.187          | 10.201    | 18.895          | 17.044    | 3.950           | 6.613     | 8.083           | 7.764     | 17.462          | 15.652    | 0.000           | 5.652     | 7.010           | 7.254     | 15.801          | 14.630    | -3.562          | 3.435     |                 |           |                 |           |                 |           |
|      |                       | W3.728.hp       | 10.043          | 9.308     | 17.658          | 16.639    | -1.075          | 3.670     | 6.857           | 6.749     | 15.980          | 15.101    | -5.652          | 0.000     | 5.905           | 4.289     | 14.294          | 13.969    | -6.638          | -1.170    |                 |           |                 |           |                 |           |
|      |                       | W4.182.asinh-hp | 6.051           | 3.379     | 8.890           | 7.668     | -6.072          | -5.097    | 0.888           | -0.107    | 7.493           | 6.211     | -7.010          | -5.905    | 0.000           | 0.489     | 6.574           | 5.598     | -9.004          | -6.328    |                 |           |                 |           |                 |           |
|      |                       | W4.182.hp       | 5.312           | 4.379     | 9.188           | 8.417     | -6.314          | -5.434    | 0.246           | -0.757    | 7.654           | 6.875     | -7.254          | -6.289    | -0.468          | 0.000     | 6.541           | 6.171     | -8.208          | -6.725    |                 |           |                 |           |                 |           |
|      |                       | W4.364.asinh-hp | -2.312          | -3.741    | 6.791           | 3.803     | -14.020         | -12.820   | -7.023          | -7.686    | 5.555           | 0.662     | -15.801         | -14.294   | -5.674          | -4.541    | 0.000           | -1.624    | -17.677         | -15.340   |                 |           |                 |           |                 |           |
|      |                       | W4.364.hp       | -1.551          | -3.273    | 7.400           | 6.661     | -13.162         | -12.504   | -5.871          | -7.394    | 4.995           | 4.612     | -14.630         | -13.969   | -5.598          | -6.171    | 1.824           | 0.000     | -16.133         | -14.933   |                 |           |                 |           |                 |           |
|      |                       | W4.728.asinh-hp | 12.439          | 11.372    | 20.128          | 18.172    | 5.282           | 7.511     | 9.215           | 8.881     | 18.750          | 16.818    | 3.582           | 6.638     | 8.004           | 8.208     | 17.077          | 16.133    | 0.000           | 7.836     |                 |           |                 |           |                 |           |
|      |                       | W4.728.hp       | 10.659          | 9.910     | 19.318          | 17.261    | -0.261          | 3.500     | 7.341           | 7.255     | 16.623          | 15.736    | -3.435          | 1.170     | 6.328           | 6.725     | 15.340          | 14.933    | -7.836          | 0.000     |                 |           |                 |           |                 |           |

Figure 45: Diebold-Mariano Test for wind power forecasts (DK1)

| Area | Dates                 | Model 1         | W2_182_asinh-hp | W2_182_hp | W2_244_asinh-hp | W2_244_hp | W2_364_asinh-hp | W2_364_hp | W2_728_asinh-hp | W2_728_hp | W3_182_asinh-hp | W3_182_hp | W3_244_asinh-hp | W3_244_hp | W3_364_asinh-hp | W3_364_hp | W3_728_asinh-hp | W3_728_hp | W4_182_asinh-hp | W4_182_hp | W4_244_asinh-hp | W4_244_hp | W4_364_asinh-hp | W4_364_hp | W4_728_asinh-hp | W4_728_hp |
|------|-----------------------|-----------------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|
| DK1  | 2019-05-13-2020-05-12 | W2.182.asinh-hp | 0.000           | 2.642     | 1.672           | -0.401    | -10.243         | -9.508    | -7.807          | -7.311    | -1.283          | -2.626    | -10.877         | -9.901    | -9.521          | -7.833    | -2.793          | -3.401    | -12.066         | -10.480   |                 |           |                 |           |                 |           |
|      |                       | W2.182.hp       | 2.642           | 0.000     | 3.248           | 0.978     | -9.794          | -9.317    | -5.049          | -7.101    | -0.095          | -1.759    | -10.508         | -9.826    | -7.366          | -7.461    | -1.700          | -2.655    | -11.657         | -10.376   |                 |           |                 |           |                 |           |
|      |                       | W2.364.asinh-hp | -1.672          | -3.248    | 0.000           | -5.374    | -17.404         | -16.994   | -5.924          | -4.688    | -5.686          | -5.750    | -17.460         | -16.262   | -7.747          | -7.599    | -7.719          | -8.432    | -18.539         | -16.760   |                 |           |                 |           |                 |           |
|      |                       | W2.364.hp       | 0.401           | -0.978    | 5.374           | 0.000     | -14.711         | -14.022   | -4.025          | -4.885    | -1.540          | -5.515    | -15.177         | -15.199   | -6.005          | -6.025    | -3.717          | -5.542    | -16.020         | -15.611   |                 |           |                 |           |                 |           |
|      |                       | W2.728.asinh-hp | 10.243          | 9.794     | 17.404          | 14.771    | 0.000           | 1.397     | 5.844           | 6.052     | 12.656          | 11.139    | -3.255          | -3.050    | 3.434           | 4.065     | 10.830          | 9.914     | -4.506          | -1.224    |                 |           |                 |           |                 |           |
|      |                       | W2.728.hp       | 9.509           | 9.317     | 16.094          | 14.922    | -1.397          | 0.000     | 5.355           | 5.968     | 11.951          | 11.095    | 0.000           | 2.483     | 4.317           | 4.982     | 13.067          | 11.786    | -4.561          | -2.543    |                 |           |                 |           |                 |           |
|      |                       | W3.182.asinh-hp | 7.807           | 5.049     | 5.924           | 4.025     | -5.843          | -5.353    | 0.000           | -0.397    | 3.829           | 2.105     | -6.964          | -6.120    | -5.071          | -2.794    | 2.415           | 1.434     | -7.993          | -6.502    |                 |           |                 |           |                 |           |
|      |                       | W3.182.hp       | 7.311           | 7.101     | 6.689           | 4.895     | -6.053          | -5.658    | 0.397           | 0.000     | 4.410           | 2.823     | -7.213          | -6.523    | -3.701          | -3.257    | 2.854           | 1.944     | -8.260          | -6.955    |                 |           |                 |           |                 |           |
|      |                       | W3.364.asinh-hp | 1.283           | 0.095     | 5.686           | 1.540     | -12.855         | -11.951   | -3.829          | -4.410    | 0.000           | -3.987    | 15.432          | 13.815    | -5.917          | -5.580    | -5.848          | -5.375    | -16.634         | -14.349   |                 |           |                 |           |                 |           |
|      |                       | W3.364.hp       | 2.621           | 1.759     | 7.570           | 5.515     | -11.139         | -11.095   | -2.165          | -2.823    | 3.987           | 0.000     | -13.186         | -12.991   | -4.394          | -4.268    | 0.052           | -3.518    | -14.130         | -13.452   |                 |           |                 |           |                 |           |
|      |                       | W3.728.asinh-hp | 10.877          | 10.508    | 17.460          | 15.177    | 3.255           | 3.488     | 6.964           | 7.213     | 15.432          | 13.185    | 0.000           | 2.483     | 4.317           | 4.982     | 13.067          | 11.786    | -3.168          | 1.358     |                 |           |                 |           |                 |           |
|      |                       | W3.728.hp       | 9.961           | 9.829     | 16.262          | 15.189    | 0.850           | 2.519     | 6.120           | 6.523     | 13.815          | 12.991    | -2.483          | 0.000     | 3.668           | 4.396     | 11.647          | 11.465    | -3.877          | -0.958    |                 |           |                 |           |                 |           |
|      |                       | W4.182.asinh-hp | 9.521           | 7.366     | 7.747           | 6.005     | -3.434          | -3.070    | 0.074           | 3.707     | 5.917           | 4.394     | -4.317          | -3.668    | 0.000           | 1.404     | 4.897           | 3.900     | -5.128          | -3.946    |                 |           |                 |           |                 |           |
|      |                       | W4.182.hp       | 7.833           | 7.461     | 7.599           | 6.035     | -4.065          | -3.736    | 2.794           | 3.257     | 5.580           | 4.268     | -4.962          | -4.396    | -4.040          | 0.000     | 4.419           | 3.715     | -5.775          | -4.891    |                 |           |                 |           |                 |           |
|      |                       | W4.364.asinh-hp | 2.798           | 1.707     | 7.719           | 3.717     | -10.048         | -2.415    | -2.856          | 5.848     | -0.052          | -13.067   | -11.647         | -4.897    | -4.419          | 0.000     | -2.105          | -14.956   | -12.620         |           |                 |           |                 |           |                 |           |
|      |                       | W4.364.hp       | 3.401           | 2.655     | 8.432           | 6.542     | -9.914          | -9.801    | -1.434          | -1.944    | 5.375           | 3.518     | -11.766         | -11.465   | -3.900          | -3.715    | 2.105           | 0.000     | -13.081         | -12.295   |                 |           |                 |           |                 |           |
|      |                       | W4.728.asinh-hp | 12.066          | 11.657    | 18.559          | 16.050    | 4.506           | 4.561     | 7.993           | 8.260     | 16.634          | 14.130    | 3.168           | 3.877     | 5.128           | 5.775     | 14.956          | 13.061    | 0.000           | 4.343     |                 |           |                 |           |                 |           |
|      |                       | W4.728.hp       | 10.480          | 10.376    | 16.780          | 15.617    | 1.224           | 2.543     | 6.502           | 6.955     | 14.349          | 13.452    | -1.358          | 0.958     | 3.946           | 4.691     | 12.620          | 12.295    | -4.343          | 0.000     |                 |           |                 |           |                 |           |

Figure 46: Diebold-Mariano Test for wind power forecasts (DK1)

| Area | Dates                 | Model 1             | W2<br>182<br>asinh-<br>hp | W2<br>182<br>hp | W2<br>364<br>asinh-<br>hp | W2<br>364<br>hp | W2<br>728<br>asinh-<br>hp | W2<br>728<br>hp | W3<br>182<br>asinh-<br>hp | W3<br>182<br>hp | W3<br>364<br>asinh-<br>hp | W3<br>364<br>hp | W3<br>728<br>asinh-<br>hp | W3<br>728<br>hp | W4<br>182<br>asinh-<br>hp | W4<br>182<br>hp | W4<br>364<br>asinh-<br>hp | W4<br>364<br>hp | W4<br>728<br>asinh-<br>hp | W4<br>728<br>hp |         |
|------|-----------------------|---------------------|---------------------------|-----------------|---------------------------|-----------------|---------------------------|-----------------|---------------------------|-----------------|---------------------------|-----------------|---------------------------|-----------------|---------------------------|-----------------|---------------------------|-----------------|---------------------------|-----------------|---------|
| DK1  | 2019.01.00-2019.05.15 | W2.182.asinh-<br>hp | 0.000                     | -3.402          | 1.196                     | -0.822          | 15.854                    | -15.171         | -8.618                    | -8.346          | -2.025                    | -3.595          | 16.664                    | 15.912          | -8.954                    | -7.787          | -3.447                    | -4.272          | -17.747                   | 16.463          |         |
|      |                       | W2.182.hp           | 3.401                     | 0.000           | 3.032                     | 0.997           | -15.071                   | -14.043         | -5.251                    | -7.768          | -0.517                    | -2.452          | -15.973                   | -15.643         | -6.496                    | -6.958          | -1.969                    | -3.220          | -16.979                   | -16.232         |         |
|      |                       | W2.364.asinh-<br>hp | -1.198                    | -3.032          | 0.000                     | -5.042          | -23.111                   | -22.281         | -6.032                    | -4.900          | -6.498                    | -8.542          | -23.466                   | -22.741         | -7.017                    | -7.017          | -8.382                    | -9.262          | -24.396                   | -23.222         |         |
|      |                       | W2.364.hp           | 0.822                     | -0.897          | 5.042                     | 0.000           | 20.427                    | -21.161         | -4.163                    | 5.248           | -2.119                    | -7.002          | 21.062                    | -21.715         | 5.305                     | 5.567           | -4.129                    | -7.753          | -31.810                   | -22.134         |         |
|      |                       | W2.728.asinh-<br>hp | 15.854                    | 15.071          | 23.124                    | 20.427          | 0.000                     | 1.625           | 11.034                    | 11.100          | 18.629                    | 16.760          | -5.019                    | -2.172          | 8.770                     | 8.231           | 17.075                    | 15.759          | -5.741                    | -2.288          |         |
|      |                       | W2.728.hp           | 15.171                    | 14.943          | 22.281                    | 21.161          | -1.625                    | 0.000           | 10.903                    | 10.827          | 18.116                    | 17.105          | -4.906                    | -4.705          | 8.341                     | 8.940           | 16.398                    | 16.055          | -5.664                    | -4.181          |         |
|      |                       | W3.182.asinh-<br>hp | 8.346                     | 7.768           | 6.900                     | 5.248           | -11.034                   | -10.827         | 0.940                     | 0.000           | -0.944                    | 3.965           | 1.719                     | -25.576         | -11.783                   | -3.535          | -2.117                    | 2.108           | 1.344                     | -13.551         | -12.224 |
|      |                       | W3.182.hp           | 2.028                     | 0.517           | 6.498                     | 2.118           | 18.829                    | -18.116         | -3.565                    | -4.278          | 2.545                     | 4.278           | -12.640                   | -12.213         | -2.142                    | -1.958          | 2.783                     | 1.742           | -13.594                   | -12.696         |         |
|      |                       | W3.364.asinh-<br>hp | 3.995                     | 2.452           | 8.542                     | 7.002           | -18.696                   | -17.165         | -1.719                    | 2.545           | 4.419                     | 0.000           | 21.517                    | 20.383          | -4.832                    | -4.665          | -5.682                    | -5.596          | -22.541                   | -20.893         |         |
|      |                       | W3.364.hp           | 16.664                    | 15.973          | 23.496                    | 21.082          | 5.019                     | 4.906           | 12.576                    | 12.644          | 21.537                    | 18.996          | 0.000                     | 2.375           | 10.022                    | 10.490          | 19.599                    | 17.904          | -3.030                    | 1.456           |         |
|      |                       | W4.182.asinh-<br>hp | 15.912                    | 15.643          | 22.741                    | 21.715          | 2.172                     | 4.705           | 11.783                    | 12.218          | 20.383                    | 19.438          | -2.375                    | 0.000           | 9.392                     | 10.069          | 18.491                    | 18.205          | -3.707                    | 0.818           |         |
|      |                       | W4.182.hp           | 8.954                     | 6.490           | 7.017                     | 5.955           | -8.770                    | -8.341          | 3.538                     | 2.142           | 4.832                     | 3.220           | -10.026                   | -9.932          | 0.000                     | 0.800           | 3.781                     | 2.724           | -10.779                   | -9.720          |         |
|      |                       | W4.182.hp           | 7.767                     | 6.956           | 7.017                     | 5.567           | -9.231                    | -8.949          | 2.117                     | 1.958           | 4.665                     | 3.214           | -10.494                   | -10.069         | -0.800                    | 0.000           | 3.509                     | 2.659           | -11.189                   | -10.395         |         |
|      |                       | W4.364.asinh-<br>hp | 3.447                     | 1.981           | 8.382                     | 4.139           | -17.070                   | -16.396         | -2.168                    | -2.783          | 5.682                     | -0.672          | -19.969                   | -18.491         | -3.781                    | -3.509          | 0.000                     | -2.521          | -21.205                   | -19.405         |         |
|      |                       | W4.364.hp           | 4.278                     | 3.220           | 9.282                     | 7.753           | -15.759                   | -16.065         | -1.044                    | -1.742          | 5.598                     | 3.261           | -17.949                   | -18.205         | -2.724                    | -2.659          | 2.521                     | 0.000           | -19.011                   | -19.015         |         |
|      |                       | W4.728.asinh-<br>hp | 17.747                    | 16.979          | 23.496                    | 21.810          | 5.741                     | 5.664           | 13.551                    | 13.594          | 22.541                    | 19.793          | 3.030                     | 3.707           | 10.779                    | 11.189          | 21.205                    | 19.011          | 0.000                     | 4.066           |         |
|      |                       | W4.728.hp           | 16.463                    | 16.212          | 23.222                    | 22.134          | 2.288                     | 4.181           | 12.224                    | 12.698          | 20.893                    | 19.897          | -1.456                    | 0.818           | 9.729                     | 10.399          | 19.435                    | 19.015          | -4.066                    | 0.000           |         |

Figure 47: Diebold-Mariano Test for wind power forecasts (DK1)

| Area | Dates                 | Model 1             | W2<br>182<br>asinh-<br>hp | W2<br>182<br>hp | W2<br>364<br>asinh-<br>hp | W2<br>364<br>hp | W2<br>728<br>asinh-<br>hp | W2<br>728<br>hp | W3<br>182<br>asinh-<br>hp | W3<br>182<br>hp | W3<br>364<br>asinh-<br>hp | W3<br>364<br>hp | W3<br>728<br>asinh-<br>hp | W3<br>728<br>hp | W4<br>182<br>asinh-<br>hp | W4<br>182<br>hp | W4<br>364<br>asinh-<br>hp | W4<br>364<br>hp | W4<br>728<br>asinh-<br>hp | W4<br>728<br>hp |
|------|-----------------------|---------------------|---------------------------|-----------------|---------------------------|-----------------|---------------------------|-----------------|---------------------------|-----------------|---------------------------|-----------------|---------------------------|-----------------|---------------------------|-----------------|---------------------------|-----------------|---------------------------|-----------------|
| DK1  | 2020.01.01-2020.05.15 | W2.182.asinh-<br>hp | 0.000                     | -1.777          | -6.592                    | -7.508          | -12.741                   | -12.843         | -5.179                    | -4.943          | -8.337                    | -9.003          | -13.256                   | -13.319         | -4.714                    | -5.762          | -8.484                    | -8.626          | -13.248                   | -13.300         |
|      |                       | W2.182.hp           | 1.777                     | 0.000           | -6.542                    | -8.344          | -13.384                   | -13.841         | -3.591                    | -4.712          | -8.493                    | -9.993          | -13.959                   | -14.348         | -5.698                    | -5.501          | -8.632                    | -9.460          | -13.829                   | -14.269         |
|      |                       | W2.364.asinh-<br>hp | 6.592                     | 6.542           | 0.000                     | -4.130          | 15.229                    | -15.057         | 2.416                     | 2.640           | -6.460                    | -6.257          | -14.986                   | -15.002         | -4.138                    | -4.146          | -4.914                    | -5.576          | -14.101                   | -14.711         |
|      |                       | W2.364.hp           | 7.508                     | 6.344           | 4.130                     | 0.000           | -13.256                   | -18.040         | 3.544                     | 4.105           | -1.212                    | -4.932          | -13.261                   | -19.479         | 0.993                     | 1.353           | -1.775                    | -4.034          | -12.408                   | -14.913         |
|      |                       | W2.728.asinh-<br>hp | 12.741                    | 13.390          | 15.229                    | 13.256          | 0.000                     | -4.121          | 9.341                     | 10.224          | 10.879                    | 9.341           | -3.096                    | -5.049          | 6.620                     | 7.147           | 9.968                     | 8.944           | -2.368                    | -4.698          |
|      |                       | W2.728.hp           | 12.943                    | 13.041          | 15.057                    | 15.840          | 4.121                     | 0.000           | 9.715                     | 10.791          | 11.119                    | 11.254          | 0.584                     | -2.973          | 7.139                     | 7.792           | 10.671                    | 10.849          | 0.912                     | -2.308          |
|      |                       | W3.182.asinh-<br>hp | 5.179                     | 3.591           | -2.416                    | -3.544          | -9.341                    | -9.715          | 0.000                     | -0.136          | -4.759                    | -5.607          | -10.470                   | -10.607         | -4.071                    | -4.280          | -5.022                    | -5.355          | -10.473                   | -10.600         |
|      |                       | W3.182.hp           | 4.940                     | 4.712           | -2.640                    | -4.105          | -10.224                   | -10.791         | 0.138                     | 0.000           | -5.270                    | -6.746          | -11.470                   | -11.845         | -3.489                    | -3.128          | -5.559                    | -6.388          | -11.352                   | -11.810         |
|      |                       | W3.364.asinh-<br>hp | 8.337                     | 8.493           | 4.640                     | 4.212           | -10.879                   | -11.419         | 4.759                     | 5.270           | 0.000                     | -3.485          | -11.488                   | -13.337         | 1.633                     | 1.963           | -1.805                    | -2.788          | -12.993                   | -13.134         |
|      |                       | W3.364.hp           | 9.009                     | 9.993           | 6.257                     | 4.932           | -9.341                    | -11.354         | 5.607                     | 6.746           | 3.485                     | 0.000           | -11.460                   | -13.640         | 2.610                     | 3.130           | 2.170                     | 0.587           | -10.707                   | -13.146         |
|      |                       | W3.728.asinh-<br>hp | 13.256                    | 13.959          | 14.681                    | 13.261          | 3.098                     | -0.584          | 10.470                    | 11.433          | 13.483                    | 11.490          | 0.000                     | -3.324          | 7.478                     | 8.008           | 12.286                    | 10.932          | 0.976                     | -2.988          |
|      |                       | W3.728.hp           | 13.319                    | 13.948          | 15.052                    | 15.475          | 5.049                     | 2.973           | 10.607                    | 11.845          | 13.337                    | 13.640          | 3.324                     | 0.000           | 7.850                     | 8.530           | 12.475                    | 12.993          | 3.094                     | 0.924           |
|      |                       | W4.182.asinh-<br>hp | 6.714                     | 5.695           | 0.133                     | -0.993          | -6.629                    | -7.163          | 4.074                     | 3.495           | -1.633                    | -2.610          | -7.478                    | -7.850          | 0.000                     | 0.739           | -1.969                    | -2.558          | -7.328                    | -7.749          |
|      |                       | W4.182.hp           | 5.762                     | 5.501           | -0.146                    | -1.353          | -7.147                    | -7.791          | 2.820                     | 3.216           | -1.963                    | -3.130          | -8.008                    | -8.530          | -0.735                    | 0.000           | -2.334                    | -3.118          | -7.781                    | -8.384          |
|      |                       | W4.364.asinh-<br>hp | 8.484                     | 8.832           | 4.914                     | 1.775           | -9.864                    | -10.671         | 5.024                     | 5.559           | 1.805                     | -2.170          | -12.485                   | 1.969           | 2.334                     | 0.000           | -2.053                    | -12.018         | -12.275                   |                 |
|      |                       | W4.364.hp           | 8.626                     | 9.460           | 5.576                     | 4.034           | -8.944                    | -10.848         | 5.355                     | 6.388           | 2.738                     | -0.587          | -10.923                   | -12.893         | 2.558                     | 3.118           | 2.053                     | 0.000           | -10.191                   | -12.501         |
|      |                       | W4.728.asinh-<br>hp | 13.246                    | 13.829          | 14.101                    | 12.408          | 2.386                     | -0.812          | 10.473                    | 11.380          | 12.993                    | 10.707          | -0.974                    | -3.094          | 7.326                     | 7.781           | 12.018                    | 10.191          | 0.000                     | -3.139          |
|      |                       | W4.728.hp           | 13.300                    | 14.269          | 14.711                    | 14.913          | 4.698                     | 2.308           | 10.600                    | 11.810          | 13.134                    | 13.146          | 2.988                     | -0.924          | 7.749                     | 8.384           | 12.375                    | 12.501          | 3.139                     |                 |

Figure 48: Diebold-Mariano Test for wind power forecasts (DK1)

| Area | Dates                 | Model 1             | W1<br>728 | W2<br>182 | W2<br>364 | W2<br>728 | W2<br>asinh-<br>hp | W3<br>182 | W3<br>364 | W3<br>728 | W3<br>asinh-<br>hp | W4<br>182 | W4<br>364 | W4<br>728 | W4<br>asinh-<br>hp |
|------|-----------------------|---------------------|-----------|-----------|-----------|-----------|--------------------|-----------|-----------|-----------|--------------------|-----------|-----------|-----------|--------------------|
| DK2  | 2019.01.01-2019.12.31 | W1.728              | 0.000     | -7.716    | -2.480    | -3.385    | -5.141             | -8.930    | -10.782   | -3.392    | -5.060             | -3.753    | -5.831    |           |                    |
|      |                       | W2.182              | 7.716     | 0.000     | 8.550     | 4.042     | 1.136              | -4.090    | -7.964    | 5.917     | 2.454              | 3.322     | 0.154     |           |                    |
|      |                       | W2.364              | 2.480     | -8.550    | 0.000     | -2.602    | -5.589             | -9.348    | -12.243   | -2.600    | -6.103             | -3.095    | -6.340    |           |                    |
|      |                       | W2.728              | 3.385     | -4.042    | 2.602     | 0.000     | -9.647             | -5.758    | -8.914    | 0.807     | -2.345             | -1.631    | -7.931    |           |                    |
|      |                       | W2.728.asinh-<br>hp | 5.141     | -1.136    | 5.589     | 9.647     | 0.000              | -3.024    | -6.253    | 3.817     | 1.171              | 4.921     | -2.741    |           |                    |
|      |                       | W3.182              | 8.930     | 4.090     | 9.348     | 5.758     | 3.024              | 0.000     | -7.383    | 9.189     | 5.220              | 5.468     | 2.192     |           |                    |
|      |                       | W3.182              |           |           |           |           |                    |           |           |           |                    |           |           |           |                    |

|                           |              |         | W1<br>728 | W2<br>182 | W2<br>364 | W2<br>728 | W2<br>728<br>asinh | W3<br>182 | W3<br>182<br>asinh | W3<br>364 | W3<br>364<br>asinh | W3<br>728 | W3<br>728<br>asinh |
|---------------------------|--------------|---------|-----------|-----------|-----------|-----------|--------------------|-----------|--------------------|-----------|--------------------|-----------|--------------------|
| Area                      | Dates        | Model 1 |           |           |           |           |                    |           |                    |           |                    |           |                    |
| DK2 2019.05.13-2020.05.12 | W1.728       | 0.000   | -12.972   | -6.299    | -4.783    | -4.606    | -14.333            | -14.697   | -7.340             | -7.594    | -5.149             | -5.166    |                    |
|                           | W2.182       | 12.972  | 0.000     | 11.993    | 9.789     | 8.322     | -5.382             | -7.924    | 8.037              | 5.548     | 8.696              | 7.192     |                    |
|                           | W2.364       | 6.299   | -11.993   | 0.000     | 2.167     | 0.937     | -12.614            | -14.270   | -3.546             | -5.445    | 0.882              | -0.327    |                    |
|                           | W2.728       | 4.783   | 9.789     | -2.167    | 0.000     | 1.961     | -11.427            | -13.386   | -4.016             | -5.654    | -1.885             | -3.162    |                    |
|                           | W2.728.asinh | 4.606   | -8.322    | -0.937    | 1.961     | 0.000     | -10.165            | -12.629   | -2.835             | -4.874    | -0.123             | -2.331    |                    |
|                           | W3.182       | 14.333  | 5.382     | 12.614    | 11.427    | 10.165    | 0.000              | -5.698    | 12.651             | 9.496     | 11.556             | 9.906     |                    |
|                           | W3.182.asinh | 14.697  | 7.924     | 14.270    | 13.386    | 12.629    | 5.698              | 0.000     | 14.194             | 12.762    | 13.544             | 12.520    |                    |
|                           | W3.364       | 7.340   | -8.037    | 3.546     | 4.016     | 2.835     | -12.651            | -14.194   | 0.000              | -4.192    | 3.491              | 1.846     |                    |
|                           | W3.364.asinh | 7.594   | -5.548    | 5.445     | 5.654     | 4.874     | -9.496             | -12.762   | 4.192              | 0.000     | 5.262              | 4.032     |                    |
|                           | W3.728       | 5.149   | -8.696    | -0.882    | 1.885     | 0.123     | -11.556            | -13.544   | -3.491             | -5.262    | 0.000              | -2.687    |                    |
|                           | W3.728.asinh | 5.166   | -7.192    | 0.327     | 3.162     | 2.331     | -9.906             | -12.520   | -1.846             | -4.032    | 2.687              | 0.000     |                    |

Figure 50: Diebold-Mariano Test for wind power forecasts (DK2)

|                           |              |         | W1<br>728 | W2<br>182 | W2<br>364 | W2<br>728 | W2<br>728<br>asinh | W3<br>182 | W3<br>182<br>asinh | W3<br>364 | W3<br>364<br>asinh | W3<br>728 | W3<br>728<br>asinh |
|---------------------------|--------------|---------|-----------|-----------|-----------|-----------|--------------------|-----------|--------------------|-----------|--------------------|-----------|--------------------|
| Area                      | Dates        | Model 1 |           |           |           |           |                    |           |                    |           |                    |           |                    |
| DK2 2019.01.01-2020.05.12 | W1.728       | 0.000   | -8.590    | -1.737    | -1.066    | -2.570    | -11.161            | -12.368   | -3.806             | -5.255    | -2.003             | -3.890    |                    |
|                           | W2.182       | 8.590   | 0.000     | 11.770    | 8.556     | 5.664     | -6.954             | -9.764    | 6.914              | 3.314     | 7.056              | 3.824     |                    |
|                           | W2.364       | 1.737   | -11.770   | 0.000     | 0.819     | -2.147    | -13.616            | -15.569   | -5.308             | -8.027    | -0.915             | -4.131    |                    |
|                           | W2.728       | 1.066   | -8.556    | -0.819    | 0.000     | -6.873    | -11.232            | -13.644   | -3.817             | -6.631    | -3.302             | -8.065    |                    |
|                           | W2.728.asinh | 2.570   | -5.664    | 2.147     | 6.873     | 0.000     | -8.550             | -11.396   | -0.830             | -3.849    | 2.127              | -4.593    |                    |
|                           | W3.182       | 11.161  | 6.954     | 13.616    | 11.232    | 8.550     | 0.000              | -6.751    | 12.616             | 8.101     | 10.753             | 7.298     |                    |
|                           | W3.182.asinh | 12.368  | 9.764     | 15.569    | 13.644    | 11.396    | 6.751              | 0.000     | 14.668             | 11.968    | 13.262             | 10.273    |                    |
|                           | W3.364       | 3.806   | -6.914    | 5.308     | 3.817     | 0.830     | -12.616            | -14.668   | 0.000              | -6.076    | 2.520              | -1.369    |                    |
|                           | W3.364.asinh | 5.255   | -3.314    | 8.027     | 6.631     | 3.849     | -8.101             | -11.968   | 6.076              | 0.000     | 5.642              | 1.724     |                    |
|                           | W3.728       | 2.003   | -7.056    | 0.915     | 3.302     | -2.127    | -10.753            | -13.262   | -2.520             | -5.642    | 0.000              | -8.596    |                    |
|                           | W3.728.asinh | 3.890   | -3.824    | 4.131     | 8.065     | 4.593     | -7.298             | -10.273   | 1.369              | -1.724    | 8.596              | 0.000     |                    |

Figure 51: Diebold-Mariano Test for wind power forecasts (DK2)

|                           |              |         | W1<br>728 | W2<br>182 | W2<br>364 | W2<br>728 | W2<br>728<br>asinh | W3<br>182 | W3<br>182<br>asinh | W3<br>364 | W3<br>364<br>asinh | W3<br>728 | W3<br>728<br>asinh |
|---------------------------|--------------|---------|-----------|-----------|-----------|-----------|--------------------|-----------|--------------------|-----------|--------------------|-----------|--------------------|
| Area                      | Dates        | Model 1 |           |           |           |           |                    |           |                    |           |                    |           |                    |
| DK2 2020.01.01-2020.05.12 | W1.728       | 0.000   | -3.986    | 0.454     | 4.221     | 3.843     | -6.710             | -6.137    | -1.813             | -2.013    | 2.857              | 2.426     |                    |
|                           | W2.182       | 3.986   | 0.000     | 8.836     | 10.982    | 10.507    | -6.584             | -5.765    | 3.577              | 2.369     | 9.092              | 8.309     |                    |
|                           | W2.364       | -0.454  | -8.836    | 0.000     | 7.381     | 6.971     | -10.846            | -9.853    | -5.435             | -5.311    | 4.140              | 3.637     |                    |
|                           | W2.728       | -4.221  | -10.982   | -7.381    | 0.000     | 1.353     | -12.832            | -11.778   | -9.232             | -8.577    | -3.759             | -2.483    |                    |
|                           | W2.728.asinh | -3.843  | -10.507   | -6.971    | -1.353    | 0.000     | -12.505            | -12.161   | -9.069             | -9.660    | -3.552             | -4.447    |                    |
|                           | W3.182       | 6.710   | 6.584     | 10.846    | 12.832    | 12.505    | 0.000              | -0.339    | 9.344              | 7.136     | 12.777             | 11.820    |                    |
|                           | W3.182.asinh | 6.137   | 5.765     | 9.853     | 11.778    | 12.161    | 0.339              | 0.000     | 8.085              | 7.170     | 11.443             | 11.392    |                    |
|                           | W3.364       | 1.813   | -3.577    | 5.435     | 9.232     | 9.069     | -9.344             | -8.085    | 0.000              | -1.652    | 8.924              | 7.778     |                    |
|                           | W3.364.asinh | 2.013   | -2.369    | 5.311     | 8.577     | 9.660     | -7.136             | -7.170    | 1.652              | 0.000     | 7.867              | 8.442     |                    |
|                           | W3.728       | -2.857  | -9.092    | -4.140    | 3.759     | 3.552     | -12.777            | -11.443   | -8.924             | -7.867    | 0.000              | 0.124     |                    |
|                           | W3.728.asinh | -2.426  | -8.309    | -3.637    | 2.483     | 4.447     | -11.820            | -11.392   | -7.778             | -8.442    | -0.124             | 0.000     |                    |

Figure 52: Diebold-Mariano Test for wind power forecasts (DK2)

### 7.1.3 Price forecasts

| Area | Dates | Model 1             | P4_182  | P4_182<br>asinh-<br>hp | P4_182<br>hp | P4_364  | P4_364<br>asinh-<br>hp | P4_364<br>hp | P4_728  | P4_728<br>asinh-<br>hp | P4_728<br>hp | P5_182  | P5_182<br>asinh-<br>hp | P5_182<br>hp | P5_728  | P5_728<br>asinh-<br>hp | P5_728<br>hp |        |
|------|-------|---------------------|---------|------------------------|--------------|---------|------------------------|--------------|---------|------------------------|--------------|---------|------------------------|--------------|---------|------------------------|--------------|--------|
|      |       | P4.182              | 0.000   | 20.277                 | 23.059       | 6.486   | 13.098                 | 13.878       | 2.594   | 11.473                 | 16.592       | 11.859  | 6.578                  | -4.806       | 11.971  | 20.010                 | -0.064       |        |
|      |       | P4.182.asinh-<br>hp | -20.277 | 0.000                  | 8.591        | -19.746 | -0.065                 | 0.978        | -10.004 | -1.659                 | 4.243        | 0.071   | -5.096                 | -21.158      | -7.439  | -1.211                 | -20.993      | -2.009 |
|      |       | P4.182.sinh-<br>hp  | 21.059  | -8.591                 | 0.000        | -20.008 | -0.623                 | 0.424        | -10.478 | -2.134                 | 3.729        | -0.405  | -5.571                 | -21.854      | -9.599  | -6.071                 | -21.109      | -2.484 |
|      |       | P4.182.hp           | -6.486  | 16.740                 | -20.609      | 0.000   | 12.763                 | 13.590       | 2.260   | 11.207                 | 16.340       | 11.672  | 6.348                  | -6.018       | 10.411  | 19.511                 | -3.249       | 10.856 |
|      |       | P4.364.as(=)        | -13.093 | 0.063                  | 0.623        | -12.763 | 0.000                  | 5.001        | -10.443 | -2.459                 | 6.782        | 0.160   | -6.578                 | -13.505      | -8.803  | -0.077                 | -13.022      | -3.168 |
|      |       | P4.364.sinh-<br>hp  | -13.678 | -0.978                 | -0.424       | -13.590 | 5.000                  | 0.000        | -19.101 | -3.957                 | 5.387        | -1.079  | -8.323                 | -14.180      | -1.803  | -1.097                 | -13.753      | -4.612 |
|      |       | P4.364.hp           | -2.594  | 10.004                 | 10.478       | -2.260  | 17.443                 | 19.101       | 0.000   | 11.478                 | 19.338       | 11.838  | 6.473                  | -3.053       | 9.153   | 9.765                  | -2.551       | 18.011 |
|      |       | P4.728              | -11.473 | 1.659                  | 2.134        | -11.207 | 2.459                  | 3.957        | -17.478 | 0.000                  | 11.267       | -2.907  | -10.471                | -11.735      | 0.921   | 1.529                  | -11.328      | -2.163 |
|      |       | P4.728.asinh-<br>hp | 16.597  | -4.243                 | -3.729       | 16.340  | 6.782                  | -5.387       | -19.336 | -11.267                | 0.000        | 9.148   | 14.964                 | 16.961       | -0.024  | -4.36                  | 16.979       | -1.784 |
|      |       | P4.728.sinh-<br>hp  | -11.859 | -0.071                 | 0.405        | -11.672 | -0.160                 | 1.079        | -11.888 | -2.907                 | 9.148        | 0.000   | -11.408                | -12.115      | -0.794  | -0.181                 | -11.806      | -3.123 |
|      |       | P4.728.hp           | -6.578  | 5.996                  | 5.571        | -6.340  | 6.578                  | 8.333        | -6.473  | 10.471                 | 14.954       | 11.428  | 0.000                  | -6.053       | 4.359   | 4.952                  | -6.492       | 7.323  |
|      |       | P5.182              | 4.806   | 21.158                 | 23.854       | 8.618   | 12.505                 | 14.180       | 3.053   | 11.798                 | 16.951       | 12.115  | 6.853                  | 0.000        | 20.209  | 21.179                 | 9.073        | 11.504 |
|      |       | P5.182.asinh-<br>hp | -8.971  | 7.439                  | 9.599        | -18.419 | 0.807                  | -1.933       | -0.921  | 5.024                  | 0.794        | -4.359  | -20.206                | 0.000        | 10.592  | -19.983                | -1.265       | 4.834  |
|      |       | P5.182.sinh-<br>hp  | -20.010 | 1.211                  | 6.071        | -19.538 | 0.077                  | 1.097        | -9.785  | -5.129                 | 4.366        | 0.189   | -4.952                 | -21.179      | -10.562 | 0.000                  | -20.466      | -1.880 |
|      |       | P5.182.hp           | 0.064   | 20.393                 | 21.198       | 3.249   | 13.022                 | 13.783       | 2.551   | 11.328                 | 16.577       | 11.806  | 6.492                  | -0.073       | 19.365  | 20.405                 | 0.000        | 11.061 |
|      |       | P5.728              | -11.149 | 2.009                  | 2.484        | -10.856 | 3.168                  | 4.612        | -18.011 | 2.163                  | 11.970       | 3.123   | -7.323                 | -11.504      | 1.265   | 1.880                  | -11.061      | 11.908 |
|      |       | P5.728.asinh-<br>hp | -13.152 | -0.422                 | 3.496        | 16.149  | 4.734                  | -5.049       | -10.499 | 1.784                  | -0.000       | -13.431 | -16.872                | -4.834       | -4.18   | -16.453                | -11.908      | 0.000  |
|      |       | P5.728.sinh-<br>hp  | -13.152 | -1.328                 | -0.856       | -12.965 | 1.845                  | -0.708       | -13.678 | -5.171                 | 7.124        | -13.053 | -13.494                | -13.430      | -2.051  | -1.448                 | -13.121      | -5.286 |
|      |       | P5.728.hp           | -8.062  | 3.887                  | 4.933        | -7.825  | 5.220                  | 6.672        | -9.183  | 8.136                  | 13.795       | 8.581   | -11.886                | -8.339       | 3.167   | 3.756                  | -7.901       | 5.373  |
|      |       | P5.728              | 0.000   | 20.277                 | 23.059       | 6.486   | 13.098                 | 13.878       | 2.594   | 11.473                 | 16.592       | 11.859  | 6.578                  | -4.806       | 11.971  | 20.010                 | -0.064       |        |

Figure 53: Diebold-Mariano Test for price forecasts (DK1)

| Area | Dates | Model 1             | P4_182 | P4_182<br>asinh-<br>hp | P4_182<br>hp | P4_364 | P4_364<br>asinh-<br>hp | P4_364<br>hp | P4_728  | P4_728<br>asinh-<br>hp | P4_728<br>hp | P5_182 | P5_182<br>asinh-<br>hp | P5_182<br>hp | P5_728 | P5_728<br>asinh-<br>hp | P5_728<br>hp |         |       |
|------|-------|---------------------|--------|------------------------|--------------|--------|------------------------|--------------|---------|------------------------|--------------|--------|------------------------|--------------|--------|------------------------|--------------|---------|-------|
|      |       | P4.182              | 0.000  | 5.229                  | 5.553        | 3.964  | -6.999                 | -5.369       | -7.622  | 5.019                  | 1.171        | 1.321  | 7.628                  | -9.062       | 3.944  | 4.592                  | -5.949       | 2.060   |       |
|      |       | P4.182.asinh-<br>hp | -5.229 | 0.000                  | 3.858        | -4.910 | -13.354                | -11.569      | -10.279 | 0.948                  | -2.557       | -2.197 | 3.242                  | -6.972       | -7.180 | -4.089                 | -6.259       | -1.758  |       |
|      |       | P4.182.sinh-<br>hp  | -5.553 | -3.858                 | 0.000        | -5.250 | -13.413                | -11.707      | 0.733   | -2.767                 | -2.421       | 3.224  | -7.274                 | -7.369       | -5.734 | -6.589                 | -1.955       | -4.401  |       |
|      |       | P4.182.hp           | -3.964 | 4.910                  | 5.250        | 0.000  | 7.124                  | -5.525       | -7.795  | 4.762                  | 0.983        | 1.145  | 7.427                  | -9.156       | 3.624  | 4.281                  | -7.475       | 1.821   |       |
|      |       | P4.364              | 6.999  | 13.354                 | 13.413       | 7.126  | 0.000                  | 13.440       | 11.957  | 9.797                  | 14.208       | 5.908  | 12.460                 | 12.773       | 6.304  | 11.108                 | 11.364       | 11.365  |       |
|      |       | P4.364.asinh-<br>hp | 5.399  | 11.569                 | 11.707       | 5.523  | 14.128                 | 0.000        | 11.698  | 9.702                  | 8.227        | 12.800 | 4.202                  | 10.527       | 10.842 | 4.641                  | 8.798        | 8.510   | 9.712 |
|      |       | P4.364.sinh-<br>hp  | 5.399  | 11.569                 | 11.707       | 5.523  | 14.128                 | 0.000        | 11.698  | 9.702                  | 8.227        | 12.800 | 4.202                  | 10.527       | 10.842 | 4.641                  | 8.798        | 8.510   | 9.712 |
|      |       | P4.364.hp           | 7.622  | 10.279                 | 10.413       | 7.754  | -0.804                 | 1.695        | 0.000   | 8.630                  | 8.027        | 7.218  | 16.171                 | 6.326        | 9.565  | 9.899                  | 6.779        | 14.374  | 7.065 |
|      |       | P4.728              | -5.019 | -0.948                 | 0.733        | -4.767 | 13.440                 | -11.468      | -16.889 | 0.000                  | -4.356       | -3.578 | 7.317                  | -6.326       | -1.860 | -1.417                 | -5.754       | -10.365 |       |
|      |       | P4.728.asinh-<br>hp | -1.771 | 2.557                  | 2.767        | -0.983 | 11.957                 | -9.702       | -8.027  | 4.956                  | 0.000        | 0.579  | 7.150                  | -2.273       | 1.563  | 2.014                  | -1.827       | 0.764   |       |
|      |       | P4.728.sinh-<br>hp  | -1.321 | 2.197                  | 2.421        | -1.145 | -9.797                 | -8.227       | 7.216   | 3.578                  | -0.579       | 0.000  | 7.161                  | -2.354       | 1.238  | 1.680                  | -1.943       | 0.402   |       |
|      |       | P4.728.hp           | -7.629 | -3.424                 | -3.224       | -7.427 | -14.208                | -12.800      | -16.171 | 7.317                  | -7.150       | -1.611 | 0.000                  | -6.738       | -4.281 | -3.871                 | -8.265       | -9.805  |       |
|      |       | P5.182              | 9.062  | 6.972                  | 7.724        | 9.156  | -5.906                 | -4.202       | -4.324  | 6.320                  | 2.273        | 2.354  | 6.738                  | 0.000        | 5.829  | 6.467                  | 8.103        | 3.452   |       |
|      |       | P5.182.asinh-<br>hp | -9.944 | 7.180                  | 7.969        | -3.624 | 12.406                 | -10.527      | -9.565  | 1.986                  | 1.563        | -1.238 | 4.281                  | -5.829       | 0.000  | 7.067                  | -5.080       | -0.871  |       |
|      |       | P5.182.sinh-<br>hp  | -4.592 | 4.089                  | 5.734        | -4.281 | 12.773                 | -10.943      | -9.899  | 1.417                  | -2.014       | -1.680 | 3.871                  | -6.467       | -7.067 | 0.000                  | 5.743        | -1.300  |       |
|      |       | P5.182.hp           | 5.949  | 6.259                  | 6.568        | 7.475  | -6.304                 | -4.641       | -6.779  | 5.754                  | 1.827        | 1.943  | 8.265                  | -8.103       | 5.080  | 5.743                  | 0.000        | 2.879   |       |
|      |       | P5.728              | -2.000 | 1.758                  | 1.955        | -1.821 | -11.108                | -8.798       | -14.374 | 10.365                 | 0.764        | -4.042 | 9.805                  | -3.452       | 0.871  | 1.300                  | -2.879       | 0.000   |       |
|      |       | P5.728.asinh-<br>hp | 0.118  | 4.215                  | 4.401        | 0.301  | 11.364                 | -8.510       | -7.065  | 6.397                  | 6.197        | 3.087  | 8.614                  | -1.007       | 3.253  | 3.690                  | -0.556       | 2.880   |       |
|      |       | P5.728.sinh-<br>hp  | -1.964 | 1.676                  | 1.906        | -1.682 | -11.898                | -9.712       | -8.101  | 3.035                  | 2.242        | -2.899 | 6.548                  | -2.941       | 0.695  | 1.159                  | -2.513       | -5.139  |       |
|      |       | P5.728.hp           | -7.891 | -3.613                 | -3.402       | -7.875 | -15.057                | -13.510      | -17.439 | 7.880                  | -7.401       | -7.076 | -0.436                 | -9.181       | -4.550 | -4.115                 | -8.673       | -12.586 |       |
|      |       | P5.728              | 0.000  | 20.277                 | 23.059       | 6.486  | 13.098                 | 13.878       | 2.594   | 11.473                 | 16.592       | 11.859 | 6.578                  | -4.806       | 11.971 | 20.010                 | -0.064       |         |       |

Figure 54: Diebold-Mariano Test for price forecasts (DK1)

| Area | Dates                 | Model 1         | P4_182  | P4_182_asinh_hp | P4_182_hp | P4_182_asinh_hp | P4_182_hp | P4_364 | P4_364_asinh_hp | P4_364_hp | P4_728 | P4_728_asinh_hp | P4_728_hp | P4_182  | P4_182_asinh_hp | P4_182_hp | P5_182  | P5_182_asinh_hp | P5_182_hp | P5_728 | P5_728_asinh_hp | P5_728_hp |
|------|-----------------------|-----------------|---------|-----------------|-----------|-----------------|-----------|--------|-----------------|-----------|--------|-----------------|-----------|---------|-----------------|-----------|---------|-----------------|-----------|--------|-----------------|-----------|
| DK1  | 2019.01.01-2020.05.12 | P4.182          | 0.000   | 14.774          | 15.060    | 10.061          | 4.935     | 5.918  | 0.629           | 10.888    | 8.502  | 5.541           | 7.463     | -3.376  | 13.684          | 14.985    | 1.628   | 9.996           | 8.360     | 6.292  | 7.852           |           |
|      |                       | P4.182_asinh    | -14.774 | 0.000           | 10.616    | -13.983         | -5.634    | -4.380 | -3.084          | 0.772     | -3.399 | -3.239          | -1.639    | -15.615 | -4.707          | 1.544     | -14.379 | -0.487          | -0.807    | -2.564 | -1.337          |           |
|      |                       | P4.182_asinh_hp | -15.660 | -10.616         | 0.000     | -14.927         | -6.291    | -5.066 | -9.650          | 0.210     | -0.965 | -3.824          | -2.169    | -16.447 | -7.894          | -2.68     | -15.285 | -1.057          | -1.422    | -3.156 | -1.870          |           |
|      |                       | P4.182_hp       | -10.061 | 13.983          | 14.927    | 0.000           | 4.443     | 5.438  | 0.080           | 10.410    | 8.141  | 5.145           | 7.056     | -6.743  | 12.887          | 14.242    | -1.856  | 9.096           | 7.902     | 5.891  | 7.443           |           |
|      |                       | P4.364_asinh    | -4.935  | 5.634           | 6.291     | -4.443          | 0.000     | 6.410  | -6.724          | 7.001     | 6.675  | 1.694           | 3.044     | -5.488  | 4.822           | 5.803     | -4.695  | 5.884           | 6.718     | 2.771  | 3.327           |           |
|      |                       | P4.364_asinh_hp | -5.018  | 4.380           | 5.066     | -5.438          | -6.410    | 0.000  | -3.331          | 5.831     | 5.207  | 0.465           | 2.079     | -6.431  | 3.554           | 4.955     | -5.665  | 4.311           | 4.938     | 1.547  | 2.548           |           |
|      |                       | P4.364_hp       | -0.623  | 9.060           | 9.652     | -0.980          | 6.729     | 0.331  | 0.000           | 17.959    | 10.222 | 4.011           | 9.639     | -1.233  | 0.304           | 9.198     | -0.358  | 16.529          | 10.312    | 7.029  | 10.673          |           |
|      |                       | P4.728          | 10.088  | -0.772          | 0.210     | 10.040          | 7.001     | 5.638  | 17.959          | 0.000     | 1.798  | 5.722           | 7.269     | -11.208 | -1.373          | 0.566     | -10.461 | -5.717          | 2.404     | 4.813  | 6.105           |           |
|      |                       | P4.728_asinh    | -0.582  | 0.369           | 0.916     | -8.141          | -6.675    | 5.205  | 10.222          | 1.798     | 0.000  | -7.818          | -1.943    | -9.028  | -0.276          | 0.597     | -8.328  | -0.185          | -1.862    | 5.767  | 1.462           |           |
|      |                       | P4.728_hp       | 5.541   | 3.239           | 3.882     | -5.145          | -1.694    | -0.468 | -6.011          | 5.722     | 7.818  | 0.000           | 2.253     | -5.938  | 2.554           | 3.389     | -5.303  | 3.606           | 5.178     | 4.213  | 2.721           |           |
|      |                       | P4.728_hp       | -7.463  | 1.639           | 2.169     | -7.056          | -3.044    | -2.078 | -8.839          | 7.269     | 1.943  | -2.253          | 0.000     | -7.768  | 1.050           | 1.805     | -7.123  | 2.677           | 1.385     | -1.133 | 1.829           |           |
|      |                       | P5.182          | 3.976   | 15.615          | 16.441    | 6.743           | 5.488     | 6.431  | 1.233           | 11.206    | 9.028  | 5.938           | 7.768     | 0.000   | 14.879          | 16.149    | 13.378  | 10.126          | 8.900     | 6.731  | 2.045           |           |
|      |                       | P5.182_asinh    | -13.684 | 4.707           | 7.894     | -12.887         | -4.822    | -3.354 | -3.864          | 1.373     | 0.276  | -2.354          | -1.050    | -16.978 | 0.000           | 13.347    | -13.673 | 0.142           | -0.121    | -1.902 | -0.754          |           |
|      |                       | P5.182_asinh_hp | -14.985 | -1.544          | 2.894     | -14.442         | -5.803    | -4.555 | -9.198          | 0.564     | -0.597 | -3.389          | -1.805    | -16.249 | -13.347         | 0.000     | -15.058 | -0.691          | -1.025    | -2.756 | -1.521          |           |
|      |                       | P5.182_hp       | -1.628  | 14.379          | 15.705    | 1.856           | 4.695     | 5.665  | 0.359           | 10.461    | 8.226  | 5.303           | 7.123     | -13.378 | 13.679          | 15.055    | 0.000   | 9.329           | 8.163     | 6.087  | 7.592           |           |
|      |                       | P5.728          | -9.996  | 0.487           | 1.057     | 9.096           | -5.664    | -4.311 | -16.525         | 5.717     | 0.185  | -3.006          | -2.677    | -10.126 | -0.142          | 0.691     | -9.329  | 0.000           | -0.423    | -2.841 | -2.279          |           |
|      |                       | P5.728_asinh    | -8.360  | 0.807           | 1.422     | -7.902          | -6.718    | -4.938 | -16.317         | 2.404     | 1.862  | -1.575          | -1.385    | -8.900  | 0.121           | 1.025     | -8.183  | 0.423           | 0.000     | -4.219 | -0.977          |           |
|      |                       | P5.728_asinh_hp | -6.292  | 2.564           | 3.156     | -5.891          | -2.771    | -1.547 | -7.029          | 4.813     | 5.767  | -4.213          | 1.133     | -6.731  | 1.902           | 2.756     | -6.087  | 2.841           | 4.219     | 0.000  | 1.725           |           |
|      |                       | P5.728_hp       | -7.852  | 1.337           | 1.870     | -7.443          | -3.527    | -2.548 | -10.073         | 6.105     | 1.482  | -2.721          | -1.929    | -8.245  | 0.754           | 1.521     | -7.592  | 2.279           | 0.977     | -1.725 | 0.000           |           |

Figure 55: Diebold-Mariano Test for price forecasts (DK1)

| Area | Dates                 | Model 1         | P4_182 | P4_182_asinh_hp | P4_182_hp | P4_182_asinh_hp | P4_182_hp | P4_364  | P4_364_asinh_hp | P4_364_hp | P4_728  | P4_728_asinh_hp | P4_728_hp | P4_182  | P4_182_asinh_hp | P4_182_hp | P5_182  | P5_182_asinh_hp | P5_182_hp | P5_728  | P5_728_asinh_hp | P5_728_hp |  |
|------|-----------------------|-----------------|--------|-----------------|-----------|-----------------|-----------|---------|-----------------|-----------|---------|-----------------|-----------|---------|-----------------|-----------|---------|-----------------|-----------|---------|-----------------|-----------|--|
| DK1  | 2020.01.01-2020.05.12 | P4.182          | 0.000  | -5.871          | 5.401     | 10.142          | -12.859   | -12.506 | -5.698          | 1.053     | -9.402  | -8.76           | 3.635     | -12.900 | -8.840          | -8.09     | -10.095 | -4.812          | -12.438   | -10.936 | -7.171          |           |  |
|      |                       | P4.182_asinh    | 5.871  | 0.000           | 6.768     | 6.481           | -12.737   | -12.288 | 0.466           | 5.140     | -7.737  | -6.700          | 7.355     | 0.974   | -9.060          | -6.924    | 1.883   | 0.060           | 11.077    | -9.721  | 3.712           |           |  |
|      |                       | P4.182_asinh_hp | 5.401  | -6.768          | 0.000     | 6.031           | -13.001   | -12.597 | 0.078           | 4.778     | -7.999  | -6.977          | 7.008     | 0.532   | -9.980          | -8.230    | 1.447   | -0.285          | -11.888   | -9.881  | 3.348           |           |  |
|      |                       | P4.182_hp       | 11.042 | -6.481          | -6.031    | 0.000           | -13.165   | -12.831 | -6.298          | 0.531     | -7.911  | -8.890          | 3.113     | -14.621 | -9.421          | -8.714    | -12.146 | -2.921          | -11.234   | -12.553 |                 |           |  |
|      |                       | P4.364_asinh    | 12.869 | 12.737          | 13.001    | 13.165          | 0.000     | 6.630   | 12.453          | 13.881    | 2.203   | 2.969           | 15.401    | 9.621   | 9.708           | 10.264    | 10.138  | 10.115          | -0.047    | 0.604   | 13.137          |           |  |
|      |                       | P4.364_asinh_hp | 12.506 | 12.288          | 12.597    | 12.831          | -6.430    | 0.000   | 11.878          | 13.450    | 1.610   | 2.400           | 15.047    | 9.200   | 9.112           | 9.712     | 9.734   | 9.554           | -2.811    | -0.135  | 12.659          |           |  |
|      |                       | P4.364_hp       | 5.698  | -0.466          | 0.076     | 2.686           | -12.453   | -11.878 | 0.000           | 6.103     | -7.225  | -6.303          | 8.610     | 0.473   | -3.085          | -2.424    | 1.426   | -0.516          | -11.118   | -9.256  | 4.583           |           |  |
|      |                       | P4.728          | -1.033 | -5.140          | -4.778    | -0.531          | -13.881   | -13.450 | -6.103          | 0.000     | -15.419 | -12.271         | 24.767    | -4.497  | -7.089          | -6.526    | -3.754  | -13.979         | -17.039   | -15.310 | -4.920          |           |  |
|      |                       | P4.728_asinh    | 8.576  | 6.700           | 6.977     | 8.890           | -2.919    | -2.400  | 6.303           | 12.271    | -4.031  | 0.000           | 14.555    | 5.783   | 4.346           | 4.793     | 6.254   | 6.846           | -7.831    | -5.614  | 10.262          |           |  |
|      |                       | P4.728_hp       | -3.635 | -7.355          | -7.096    | -3.113          | -15.401   | -15.047 | -8.610          | -14.767   | -15.432 | -14.557         | 0.000     | -6.757  | -9.111          | -8.576    | -4.038  | -15.439         | -18.470   | -17.225 | -11.017         |           |  |
|      |                       | P5.182          | 12.900 | -0.974          | -0.532    | 14.621          | -9.621    | -9.200  | -0.473          | -4.497    | -0.567  | -5.783          | 6.757     | 0.000   | -4.254          | -4.742    | 13.407  | -0.776          | -9.578    | -8.027  | 3.217           |           |  |
|      |                       | P5.182_asinh    | 8.840  | 9.060           | 9.980     | 9.421           | -9.708    | -9.112  | 3.085           | 7.089     | -5.280  | -4.93           | 9.111     | 4.254   | 2.050           | 0.000     | 13.369  | 5.196           | 2.425     | -9.172  | 6.632           |           |  |
|      |                       | P5.182_asinh_hp | 8.099  | 6.924           | 8.220     | 8.714           | -10.269   | -9.712  | 2.424           | 6.526     | -5.733  | -4.798          | 8.578     | 3.472   | -10.369         | 0.000     | 4.440   | 1.827           | -9.612    | 8.643   | 5.428           |           |  |
|      |                       | P5.182_hp       | 10.096 | -1.803          | 1.447     | 12.146          | -10.188   | -9.734  | -1.426          | 3.754     | -7.041  | -6.254          | 6.038     | -13.407 | -5.196          | -4.440    | 0.000   | 1.552           | -10.032   | -9.501  | 2.405           |           |  |
|      |                       | P5.728          | 4.812  | -0.060          | 0.285     | 5.291           | -11.055   | -9.954  | 0.516           | 13.579    | -8.021  | -8.846          | 15.836    | 0.776   | -2.425          | -1.877    | 1.552   | 0.000           | -12.692   | -10.415 | 19.296          |           |  |
|      |                       | P5.728_asinh    | 12.438 | 11.677          | 11.888    | 12.712          | 2.047     | 2.811   | 11.118          | 17.009    | 8.313   | 9.758           | 18.701    | 14.770  | 9.578           | 9.172     | 9.612   | 10.032          | 12.692    | 0.000   | 12.757          | 15.944    |  |
|      |                       | P5.728_asinh_hp | 9.936  | 9.721           | 9.981     | 11.234          | -0.604    | 0.135   | 9.258           | 15.110    | 4.204   | 4.564           | 17.225    | 12.027  | 8.027           | 7.171     | 7.643   | 8.501           | 10.415    | -0.975  | 0.000           | 14.957    |  |
|      |                       | P5.728_hp       | 0.717  | -3.712          | -3.348    | 1.253           | 13.137    | -12.650 | -4.583          | 4.920     | 11.413  | -10.232         | 11.017    | -3.217  | -6.032          | -5.428    | -2.405  | -19.299         | -15.944   | -14.057 |                 |           |  |

Figure 56: Diebold-Mariano Test for price forecasts (DK1)

| Area | Dates                 | Model 1         | P4_182  | P4_182_asinh_hp | P4_182_hp | P4_182_asinh_hp | P4_182_hp | P4_364 | P4_364_asinh_hp | P4_364_hp | P4_728 | P4_728_asinh_hp | P4_728_hp | P4_182 | P4_182_asinh_hp | P4_182_hp | P5_182  | P5_182_asinh_hp | P5_182_hp | P5_728 | P5_728_asinh_hp | P5_728_hp |  |
|------|-----------------------|-----------------|---------|-----------------|-----------|-----------------|-----------|--------|-----------------|-----------|--------|-----------------|-----------|--------|-----------------|-----------|---------|-----------------|-----------|--------|-----------------|-----------|--|
| DK2  | 2019.01.01-2019.12.31 | P4.182          | 0.000   | 18.868          | 3.585     | -3.260          | 11.068    | 11.853 | 7.604           | 18.613    | 12.609 | 5.639           | -2.373    | 18.512 | 18.771          | -0.798    | 11.917  | 7.656           | 15.641    | 12.675 | 5.674           |           |  |
|      |                       | P4.182_asinh    | -18.567 | 0.000           | 4.818     | 18.441          | -13.891   | -1.174 | -0.330          | -3.486    | 4.481  | 1.688           | -4.713    | 18.667 | -0.417          | -2.537    | -18.560 | -0.261          | -3.427    | 4.523  | 1.763           | -6.478    |  |
|      |                       | P4.182_asinh_hp | -18.303 | 4.818           | 0.000     | 18.710          | 14.028    | -1.341 | -0.498          | -3.624    | 4.333  | 1.551           | -5.598    | -3.511 | 18.302          | 18.658    | -2.427  | 11.866          | 7.606     | 15.601 | 12.646          | 5.626     |  |
|      |                       | P4.182_hp       | -3.595  | 18.441          | 3.873     | 0.000           | -21.778   | 0.000  | 5.9             |           |        |                 |           |        |                 |           |         |                 |           |        |                 |           |  |

| Area | Dates | Model 1      | P4_182 | P4_182_asinh | P4_182_hp | P4_364 | P4_364_asinh | P4_728  | P4_728_asinh | P4_728_hp | P5_182 | P5_182_asinh | P5_182_hp | P5_364 | P5_364_asinh | P5_728 | P5_728_asinh | P5_728_hp |        |        |        |        |       |
|------|-------|--------------|--------|--------------|-----------|--------|--------------|---------|--------------|-----------|--------|--------------|-----------|--------|--------------|--------|--------------|-----------|--------|--------|--------|--------|-------|
|      |       | P4.182       | 0.000  | 2.367        | 2.344     | -0.207 | -9.905       | -6.646  | -5.840       | -0.018    | 1.075  | 1.585        | 2.356     | 4.009  | 2.385        | 2.370  | 0.263        | -5.749    | 1.200  | 1.162  | 1.627  | 2.452  |       |
|      |       | P4.182.asinh | -2.367 | 0.000        | -0.682    | -2.370 | -10.082      | -10.180 | -9.275       | -1.555    | -0.513 | 0.123        | 0.570     | -2.320 | 0.357        | 0.079  | -2.331       | -0.178    | -1.361 | -0.409 | 0.174  | 0.656  |       |
|      |       | P4.182.sinh  | -0.234 | 0.682        | 0.000     | -2.349 | -10.072      | -10.149 | -9.257       | -1.539    | -0.491 | 0.143        | 0.589     | -2.297 | 0.630        | 0.405  | -2.310       | -0.160    | -1.345 | -0.387 | 0.195  | 0.675  |       |
|      |       | P4.182.sinh  | 0.207  | 2.370        | 2.349     | 0.000  | -9.908       | -6.635  | -5.833       | -0.013    | 1.079  | 1.589        | 2.367     | 4.043  | 2.387        | 2.374  | 0.337        | -5.741    | 0.205  | 1.165  | 1.631  | 2.463  |       |
|      |       | P4.364       | 9.005  | 10.088       | 10.072    | 9.998  | 0.000        | 3.391   | 4.512        | 12.910    | 10.458 | 9.865        | 13.510    | 9.830  | 10.042       | 10.040 | 9.828        | 4.607     | 13.177 | 10.525 | 9.628  | 13.597 |       |
|      |       | P4.364.asinh | 6.646  | 10.188       | 10.149    | 6.635  | -3.391       | 0.000   | 10.994       | 7.538     | 11.235 | 10.288       | 9.306     | 6.630  | 10.126       | 10.108 | 6.617        | 10.565    | 7.789  | 11.350 | 10.337 | 9.408  |       |
|      |       | P4.364.sinh  | 5.840  | 9.275        | 9.257     | 5.833  | -4.515       | 0.000   | 6.574        | 10.098    | 9.534  | 8.556        | 5.828     | 9.223  | 9.216        | 5.818  | 1.920        | 6.822     | 10.217 | 9.575  | 8.650  |        |       |
|      |       | P4.728       | 0.018  | 1.555        | 1.539     | 0.024  | -12.910      | -7.538  | -5.874       | 0.000     | 1.653  | 2.185        | 8.048     | 0.047  | 1.564        | 1.553  | 0.037        | -0.467    | 6.285  | 1.776  | 2.236  | 8.265  |       |
|      |       | P4.728.asinh | -1.076 | 0.013        | 0.481     | -1.078 | -10.458      | -11.235 | -10.098      | -1.653    | 0.005  | 1.787        | 1.428     | -1.045 | 0.530        | 0.514  | -1.054       | -0.988    | -1.369 | 2.835  | 1.910  | 1.950  |       |
|      |       | P4.728.sinh  | 1.585  | -0.123       | -1.043    | 1.566  | -9.805       | -10.288 | -9.534       | -2.185    | -1.787 | 0.000        | 0.667     | -0.555 | -0.103       | -1.164 | -0.442       | -1.934    | -1.502 | 1.494  | 0.792  |        |       |
|      |       | P4.728.sinh  | -0.405 | 2.320        | 2.297     | 0.443  | -9.823       | -6.630  | -5.828       | -0.047    | 1.048  | 1.555        | 2.310     | 0.000  | 2.351        | 2.335  | 0.438        | -5.745    | 0.170  | 1.132  | 1.598  | 2.408  |       |
|      |       | P5.182       | -2.385 | 0.357        | -0.630    | -2.387 | -10.042      | -10.126 | -9.223       | -1.584    | -0.530 | 0.135        | 0.550     | -2.351 | 0.000        | -0.496 | -2.362       | -0.143    | -1.373 | 0.427  | 0.154  | 0.636  |       |
|      |       | P5.182.sinh  | -0.370 | -0.079       | -0.465    | -2.374 | -10.040      | -10.108 | -9.216       | -1.553    | -0.514 | 0.118        | 0.564     | -2.335 | 0.496        | 0.000  | -2.348       | -0.138    | -1.361 | -0.411 | 0.169  | 0.650  |       |
|      |       | P5.182.sinh  | 0.263  | 2.311        | 2.310     | 0.337  | -9.828       | -6.617  | -5.818       | -0.037    | 1.054  | 1.564        | 2.327     | 0.438  | 2.362        | 2.348  | 0.000        | -5.738    | 0.189  | 1.141  | 1.607  | 2.426  |       |
|      |       | P5.364       | 5.749  | 9.178        | 9.160     | 5.741  | -4.607       | -10.565 | -1.920       | 6.467     | 9.988  | 9.442        | 8.457     | 5.745  | 9.143        | 9.136  | 5.735        | 0.000     | 6.722  | 10.125 | 9.496  | 8.568  |       |
|      |       | P5.728       | -2.200 | 1.361        | 1.345     | 0.205  | 13.177       | -7.785  | -6.822       | -1.778    | -6.286 | 1.360        | 1.934     | 7.346  | -0.170       | 1.373  | 1.361        | -0.180    | -6.722 | 0.000  | 1.493  | 1.988  | 7.660 |
|      |       | P5.728.asinh | -1.160 | 0.409        | 0.387     | -1.165 | -10.525      | -11.350 | -10.217      | -1.778    | -2.893 | 1.502        | 1.297     | -1.132 | 0.427        | 0.411  | -1.141       | -10.129   | -1.493 | 0.000  | 1.643  | 1.421  |       |
|      |       | P5.728.sinh  | -0.167 | -0.174       | -0.195    | -1.631 | -9.828       | -10.327 | -9.575       | -2.236    | -1.919 | -1.494       | 0.600     | -1.596 | -0.154       | -0.169 | -1.667       | -0.498    | -1.988 | -1.643 | 0.000  | 0.726  |       |
|      |       | P5.728.sinh  | -0.452 | -0.856       | -0.675    | -2.463 | 13.597       | -9.408  | -8.660       | -8.265    | -1.550 | -0.792       | -2.902    | -2.048 | -0.636       | -0.650 | -2.426       | -0.568    | -7.660 | -1.421 | -0.726 |        |       |

Figure 58: Diebold-Mariano Test for price forecasts (DK2)

| Area | Dates | Model 1      | P4_182  | P4_182_asinh | P4_182_hp | P4_364  | P4_364_asinh | P4_728  | P4_728_asinh | P4_728_hp | P5_182 | P5_182_asinh | P5_182_hp | P5_364 | P5_364_asinh | P5_728 | P5_728_asinh | P5_728_hp |        |        |        |        |
|------|-------|--------------|---------|--------------|-----------|---------|--------------|---------|--------------|-----------|--------|--------------|-----------|--------|--------------|--------|--------------|-----------|--------|--------|--------|--------|
|      |       | P4.182       | 0.000   | 10.088       | 10.365    | 5.343   | -3.636       | 3.942   | 4.632        | 3.697     | 8.980  | 7.254        | 5.422     | 3.701  | 9.916        | 10.241 | 5.046        | 5.390     | 7.448  | 9.698  | 8.327  | 6.904  |
|      |       | P4.182.asinh | -10.088 | 0.000        | 6.021     | -9.904  | -9.685       | -3.242  | -2.410       | -0.079    | 3.341  | 1.485        | 0.718     | 0.959  | 0.179        | 2.448  | 9.329        | 1.515     | 0.904  | 4.196  | 2.695  | 0.630  |
|      |       | P4.182.sinh  | -0.365  | -0.211       | 0.000     | -10.188 | -9.981       | -3.457  | -2.628       | -0.243    | 3.152  | 1.309        | -0.876    | 0.942  | 1.635        | 0.548  | 0.911        | 1.734     | 0.740  | 3.996  | 2.520  | 0.475  |
|      |       | P4.182.sinh  | 5.434   | 9.904        | 10.188    | 0.000   | -3.769       | 3.824   | 4.521        | 6.299     | 8.883  | 7.164        | 5.332     | 2.988  | 9.733        | 10.067 | 4.073        | 5.279     | 7.333  | 9.691  | 8.239  | 6.819  |
|      |       | P4.364       | 3.632   | 9.988        | 9.981     | 3.769   | 0.000        | 10.713  | 11.046       | 11.506    | 11.648 | 11.526       | 11.775    | 4.028  | 9.951        | 9.800  | 4.210        | 12.988    | 1.757  | 15.700 | 12.733 | 13.865 |
|      |       | P4.364.asinh | 3.942   | 3.242        | 3.457     | -3.828  | -10.713      | 0.000   | 6.467        | 3.270     | 9.342  | 5.518        | 2.046     | 3.536  | 3.225        | 3.480  | 3.386        | 13.952    | 4.681  | 10.617 | 7.121  | 3.805  |
|      |       | P4.364.sinh  | -0.432  | 2.410        | 2.628     | -4.521  | -11.601      | -6.467  | 0.000        | 2.463     | 4.801  | 4.860        | 1.350     | 4.213  | 2.394        | 2.051  | -0.007       | 10.335    | 3.867  | 6.618  | 6.521  | 3.164  |
|      |       | P4.728       | 4.397   | 0.079        | 0.243     | -6.299  | -15.686      | -3.270  | 2.463        | 0.000     | 4.914  | 2.181        | -2.475    | 5.950  | 0.091        | 0.286  | 5.821        | 1.409     | 11.042 | 0.612  | 3.794  | 2.882  |
|      |       | P4.728.asinh | -8.890  | 3.344        | -3.152    | -8.883  | -16.848      | -9.342  | -8.404       | -0.000    | 5.438  | 8.620        | -3.300    | -3.084 | -3.064       | -4.862 | -2.718       | -3.320    | 10.354 | -1.549 | -3.399 |        |
|      |       | P4.728.sinh  | 7.285   | 1.494        | 1.309     | -7.164  | -11.526      | -5.518  | -4.871       | -2.161    | 5.059  | 0.000        | 3.417     | 4.872  | 1.496        | 1.247  | 4.753        | 3.780     | -0.666 | 6.606  | 16.875 | -1.125 |
|      |       | P5.182       | 5.422   | 0.718        | 0.876     | -5.332  | -11.726      | -2.046  | -1.350       | 2.475     | 5.438  | 3.417        | 0.000     | -4.977 | 0.724        | 0.909  | -4.857       | 0.477     | 5.072  | 6.220  | 5.092  | 17.876 |
|      |       | P5.182.asinh | 3.701   | 9.569        | 9.842     | -2.598  | -4.036       | 5.358   | 4.213        | 5.950     | 6.620  | 6.872        | 4.977     | 0.000  | 9.565        | 9.880  | 6.694        | 4.899     | 7.027  | 9.333  | 7.962  | 4.646  |
|      |       | P5.182.sinh  | 9.916   | -0.176       | 1.695     | -9.733  | -9.591       | -3.225  | -2.38        | -0.093    | 3.306  | 1.456        | 0.724     | 0.953  | 0.000        | 6.971  | 9.319        | 1.519     | 0.881  | 4.159  | 2.661  | 0.610  |
|      |       | P5.364       | -0.241  | 2.448        | -0.548    | -10.067 | -9.800       | -3.460  | -2.616       | -0.286    | 3.084  | 1.247        | -0.999    | 0.980  | -0.971       | 0.000  | 9.655        | 10.955    | 3.934  | 2.455  | 0.427  |        |
|      |       | P5.364.asinh | 5.040   | 9.379        | 9.631     | -4.703  | -4.210       | 3.886   | 4.067        | 5.821     | 4.802  | 6.751        | 4.871     | 0.694  | 0.311        | 9.665  | 0.000        | 4.844     | 6.901  | 9.299  | 7.846  | 6.351  |
|      |       | P5.364.sinh  | -5.390  | 1.515        | 1.734     | -5.279  | -12.588      | -13.512 | -10.335      | -1.480    | 7.218  | 3.780        | 0.477     | 4.898  | 1.512        | 1.778  | -4.844       | 0.000     | 2.88   | 8.528  | 5.485  | 2.264  |
|      |       | P5.728       | 7.448   | -0.904       | -0.740    | -7.353  | -17.577      | -4.684  | -3.867       | -11.404   | 3.320  | 0.669        | 5.072     | 7.027  | 0.883        | 0.869  | 4.900        | 2.882     | 0.000  | 4.504  | 2.288  | -0.819 |
|      |       | P5.728.asinh | 8.327   | -2.686       | -2.520    | -8.239  | -12.733      | -7.121  | -6.524       | -3.794    | 1.549  | -16.575      | 5.062     | 9.962  | 2.661        | -2.455 | 7.848        | 5.465     | -2.286 | 3.862  | 0.000  | -2.876 |
|      |       | P5.728.sinh  | -6.900  | -0.630       | -0.475    | -8.419  | -13.865      | -3.805  | -3.116       | -2.882    | 3.399  | 1.125        | -17.076   | 4.666  | -6.010       | -0.427 | -6.351       | -2.264    | 0.819  | 4.391  | 2.876  |        |

Figure 59: Diebold-Mariano Test for price forecasts (DK2)

| Area | Dates | Model 1      | P4_182 | P4_182_asinh | P4_182_hp | P4_364  | P4_364_asinh | P4_728  | P4_728_asinh | P4_728_hp | P5_182 | P5_182_asinh | P5_182_hp | P5_364 | P5_364_asinh | P5_728 | P5_728_asinh | P5_728_hp |        |        |       |       |
|------|-------|--------------|--------|--------------|-----------|---------|--------------|---------|--------------|-----------|--------|--------------|-----------|--------|--------------|--------|--------------|-----------|--------|--------|-------|-------|
|      |       | P4.182       | 0.000  | -10.694      | -10.520   | 4.671   | -1.021       | -10.105 | -0.965       | -6.738    | -5.996 | 0.711        | 4.100     | 10.563 | -10.405      | 5.658  | -9.972       | -0.709    | -6.613 | -5.888 | 0.954 |       |
|      |       | P4.182.asinh | 10.694 | 0.000        | 3.714     | 10.839  | 7.346        | -4.761  | -6.601       | 4.629     | -0.944 | 0.024        | 7.959     | 10.936 | 1.828        | 3.572  | 11.070       | -4.420    | 6.688  | -0.791 | 0.157 | 2.022 |
|      |       | P4.182.sinh  | 10.920 | -3.714       | 0.000     | 10.874  | 7.237        | -4.921  | -4.766       | -6.338    | -0.944 | 0.024        | 7.959     | 10.936 | 1.828        | 3.572  | 11.070       | -4.420    | 6.688  | -0.791 | 0.157 | 2.022 |
|      |       | P4.182.sinh  | -4.671 | 0.000        | -10.839   | -10.674 | -1.202       | -10.321 | -1.020       | -1.080    | -6.819 | -0.000       | 8.781     | 10.762 | -0.659       | 1.6    |              |           |        |        |       |       |

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