exploration

August 19, 2024

0.0.1 Key observations on these relationships

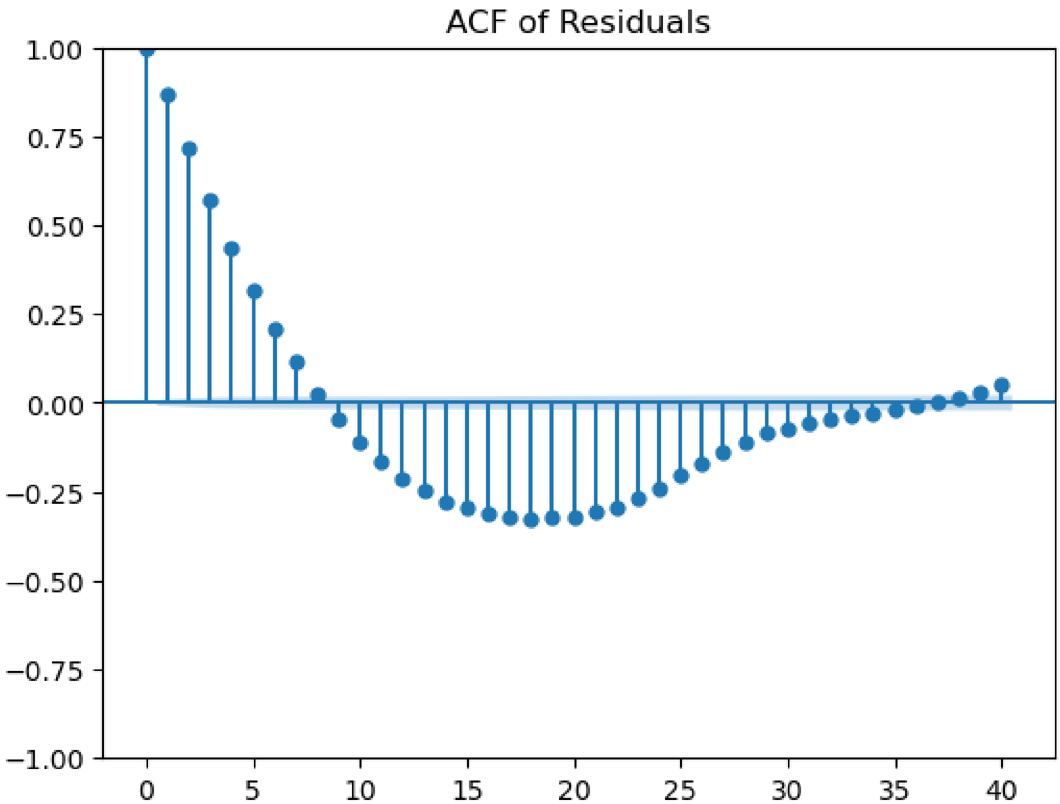
- Data utilized for training: 4 years worth half-hourly national demand and prices sourced from UK historical demand page and elexon
- Data was also scaled using minmax scaler to maintain a sensible matrix for inversion
- Note that this is an exploratory analysis whose intention is to figure out if there is a sensible linear model which can fit properties like prices and intraday volatility against demand. To simplify things, I only used the national demand which can be extended with other factors like Interconnector flows, capacity etc for a more extensive approach
- Starting off, the time series regression do make sense as the ADF test says that we are not having unit roots in residuals implying that the residuals aren't random walks.
- While the R^2 scores are low, AIC/BIC are negative implying a fair amount of positive likelihood(Regression stats are available)
- Some preprocessing I did was to remove trend/seasonality from demand / prices / vol as they had very low DW statistic implying lot of residual autocorrelation. To make forecasts on forecasted demand in future, one can remove trend/seasonality, predict using the model and add these properties back. My intention was to focus on a more generic relationship between demands and clearing prices as rest of the signals are systematic noise
- Considering the demand created by EV / residential heating, we can formulate $D_{adj} = D + f(EV, Res_{heat})$ which can mean that the prices would increase when a certain amount of the demand is driven orthogonally from the existing demand values
- However, a thing which was strange was that the overall ND was reducing over time which felt counterintuitive but could be due to the amount of outflow happening through interconnectors
- As for intraday volatility, unless $f(EV, Res_{heat})$ follows a very volatile model, I wouldn't expect it to increase as much compared to that of prices due to the low demand loading.
- A much more extensive analysis can be performed when only certain hours are shocked instead of all hours, which can effect prices significantly but would expect the impact to be lower for intraday vol as its a metric across the whole day which would lead to averaged out effect
- Summarizing, in short term, I would expect the prices and vols to increase, prices specifically but vol not as much. As someone who trades short term power, I would think cobblestone does get impacted by this in auctions and should adjust theoretical prices accordingly to maximize profits
- Below pages have plots which you can refer to, only two online resources I used were https://www.nationalgrideso.com/data-portal/historic-demand-data for demand data and elexon for prices

0.0.2 Extensions

- Slightly complicated model for demand on EV / heating would be better to work with. I have tried to find some relevant material under the time constraint but most of the research seemed to focus on psychological aspect of EV taking off which involved forms/surveys
- Maybe we can draw a parallel to US adoptions and see if any inference can be made. I initially was opposed to doing this as the demographics are very different
- Obviously linear regression isn't the best model to pinpoint the impact but is a very good starter to get an idea of impact direction and magnitude. We can try using a random forest/XGBoost by decomposing trend/seasonality, use various components of demand and make a complex model which can accurately estimate the price/vol impact. I stuck to OLS because of the interpretability

0.0.3 Analysis

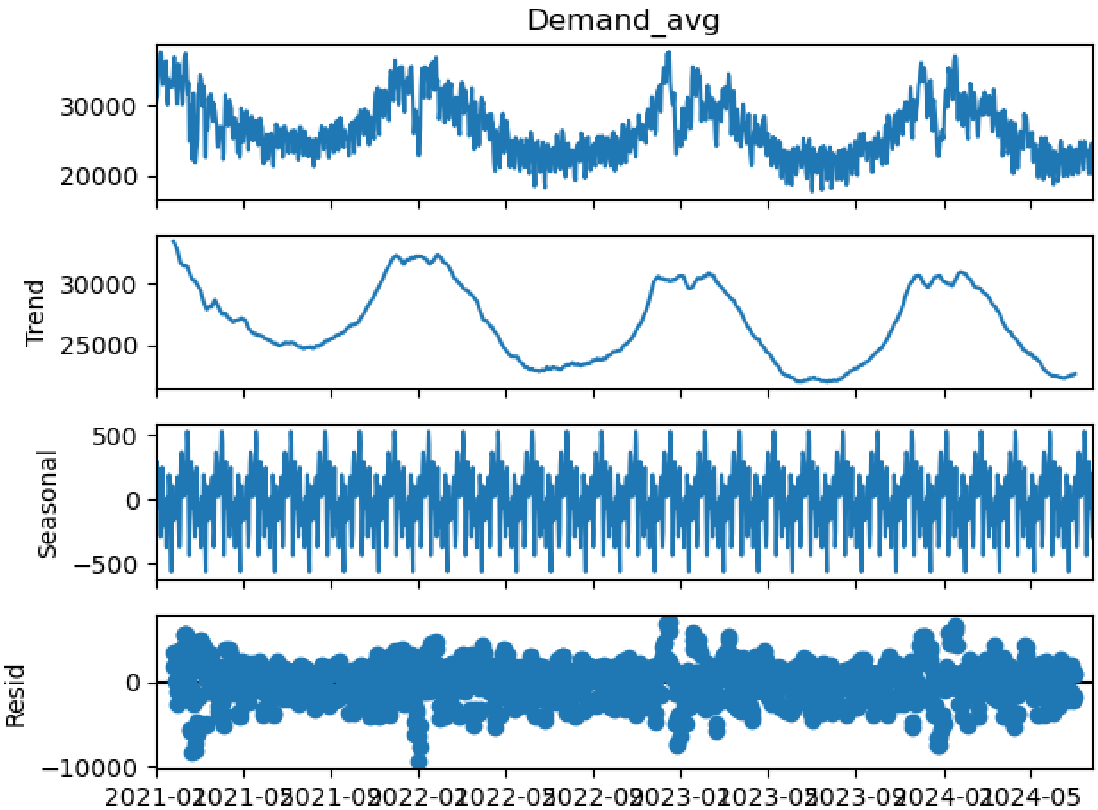
```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.088
Model:                            OLS   Adj. R-squared:                  0.088
Method:                 Least Squares   F-statistic:                     6058.
Date:                Mon, 19 Aug 2024   Prob (F-statistic):               0.00
Time:                        19:23:31   Log-Likelihood:             1.6119e+05
No. Observations:               62451   AIC:                        -3.224e+05
Df Residuals:                   62449   BIC:                        -3.224e+05
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.2274      0.000    895.216      0.000       0.227       0.228
x1             0.0393      0.001     77.834      0.000       0.038       0.040
==============================================================================
Omnibus:                    96830.375   Durbin-Watson:                   0.265
Prob(Omnibus):                  0.000   Jarque-Bera (JB):        223875298.180
Skew:                           9.275   Prob(JB):                         0.00
Kurtosis:                     295.731   Cond. No.                         8.52
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```



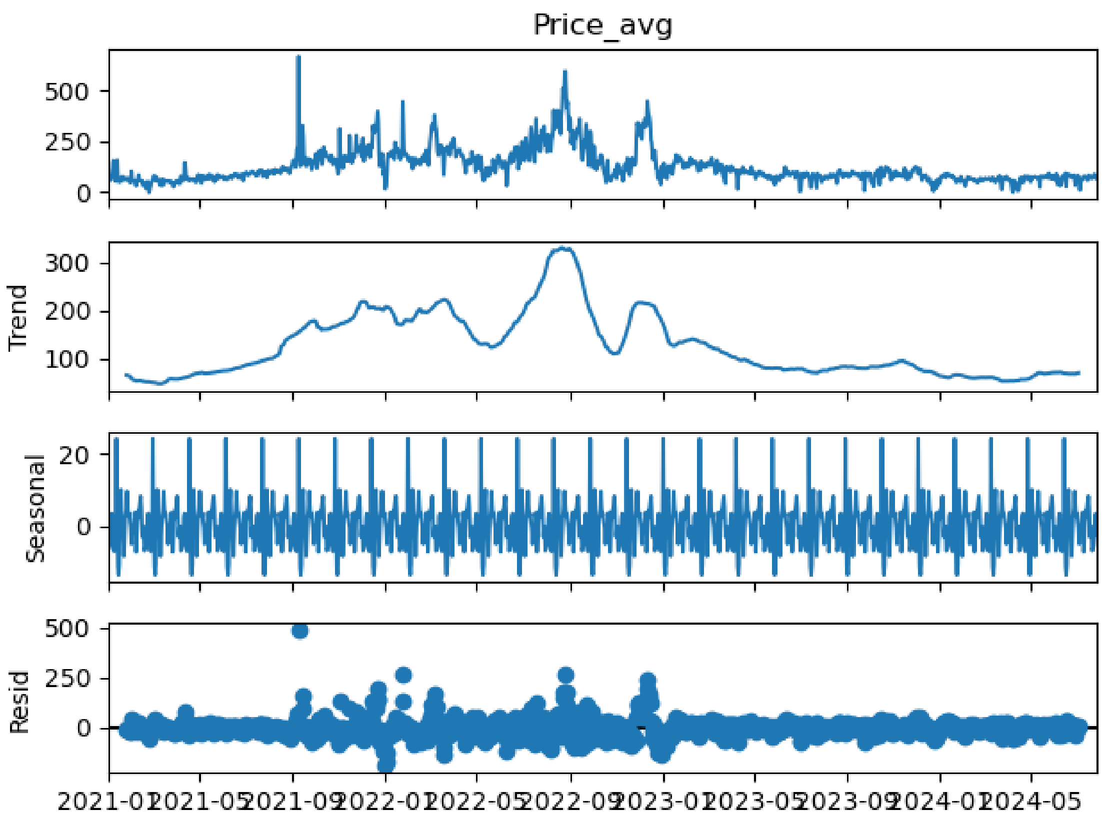

```
ADF Statistic: -54.84722149994893
p-value: 0.0
```

0.0.4 On data grouped to a daily granularity

```
<Figure size 300x300 with 0 Axes>
```

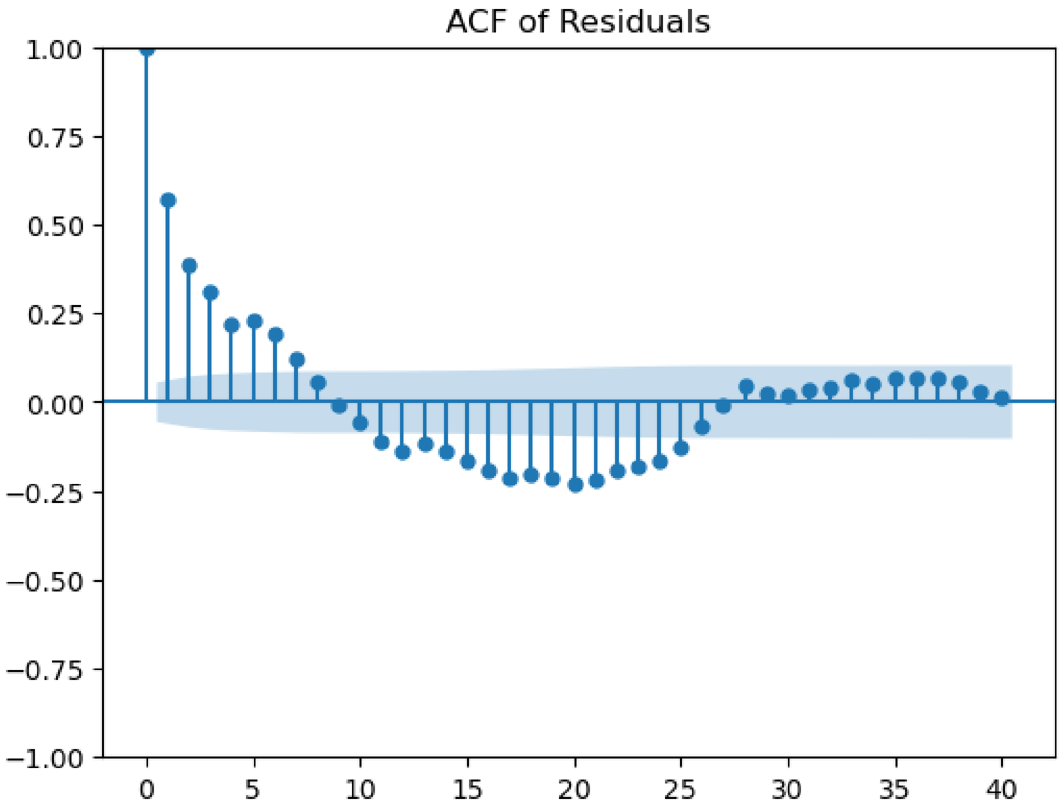


<Figure size 300x300 with 0 Axes>



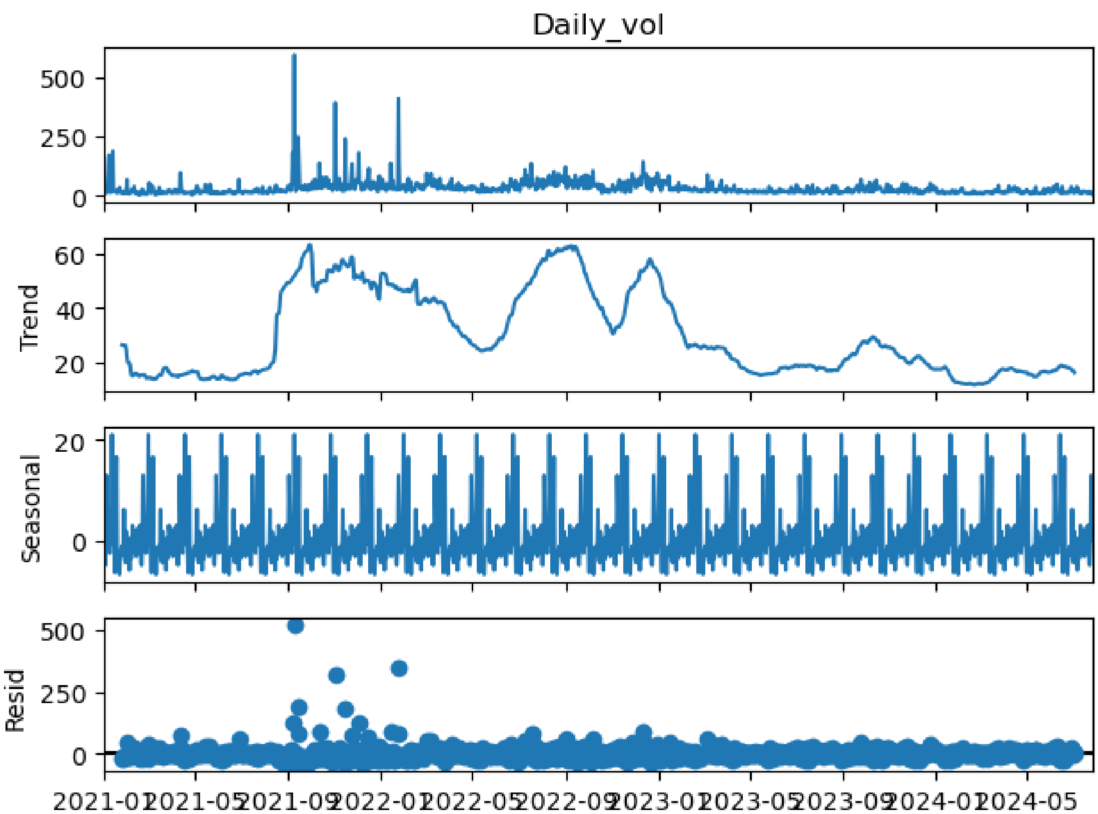

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.264
Model:                            OLS   Adj. R-squared:                  0.263
Method:                 Least Squares   F-statistic:                     448.3
Date:                Mon, 19 Aug 2024   Prob (F-statistic):           2.63e-85
Time:                        19:23:39   Log-Likelihood:                 1879.2
No. Observations:                1255   AIC:                            -3754.
Df Residuals:                    1253   BIC:                            -3744.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.1539      0.006     24.700      0.000       0.142       0.166
x1             0.2242      0.011     21.174      0.000       0.203       0.245
==============================================================================
Omnibus:                      916.523   Durbin-Watson:                   0.857
Prob(Omnibus):                  0.000   Jarque-Bera (JB):            37376.043
Skew:                           2.903   Prob(JB):                         0.00
Kurtosis:                      29.097   Cond. No.                         9.21
```

```
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```




```
ADF Statistic: -10.844320876688789
p-value: 1.5865945477557885e-19
```

```
&lt;Figure size 300x300 with 0 Axes&gt;
```




```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.008
Model:                            OLS   Adj. R-squared:                  0.007
Method:                 Least Squares   F-statistic:                     10.14
Date:                Mon, 19 Aug 2024   Prob (F-statistic):            0.00149
Time:                        19:23:41   Log-Likelihood:                 2041.1
No. Observations:                1255   AIC:                            -4078.
Df Residuals:                    1253   BIC:                            -4068.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0609      0.005     11.115      0.000       0.050       0.072
x1             0.0296      0.009      3.185      0.001       0.011       0.048
==============================================================================
Omnibus:                     1978.384   Durbin-Watson:                   1.737
Prob(Omnibus):                  0.000   Jarque-Bera (JB):          1181154.179
Skew:                           9.534   Prob(JB):                         0.00
Kurtosis:                     152.078   Cond. No.                         9.21
```

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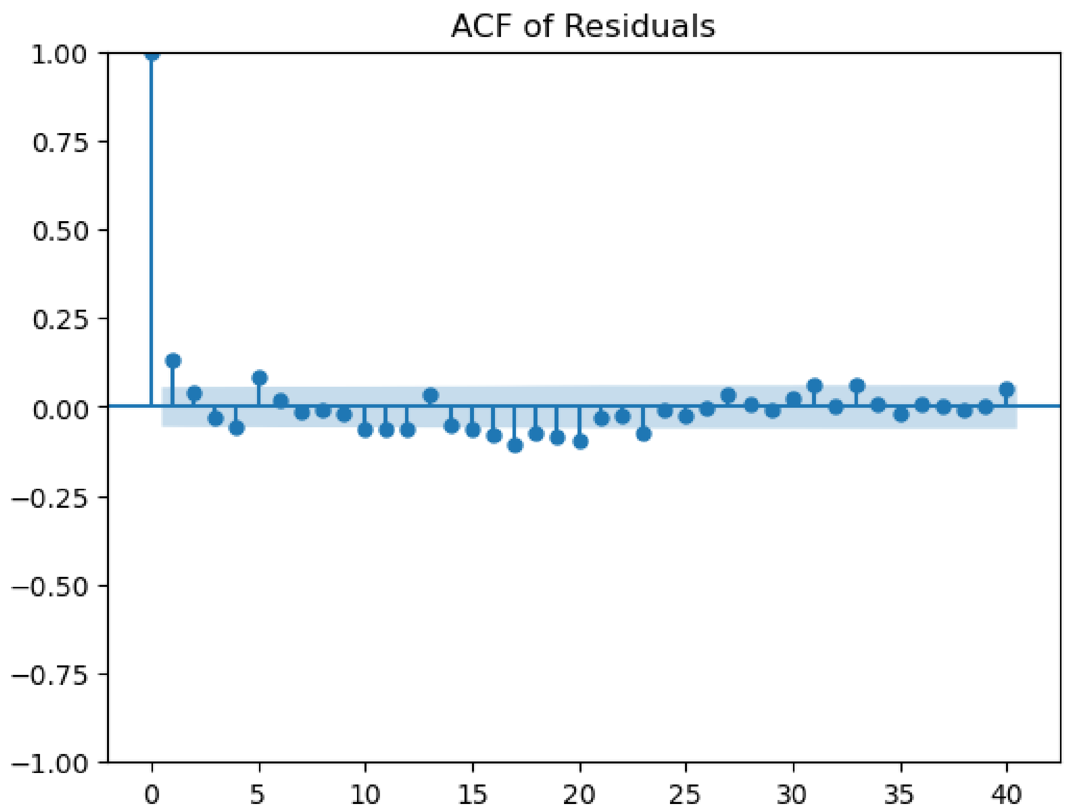
Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.



ADF Statistic: -11.90660994033187
p-value: 5.417569099155691e-22