MATØK6 project proposals - Spring 2024

Esben Høg, esben@math.aau.dk
Francesco Benvenuti, fraben@math.aau.dk

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The following proposals are given as suggestions, and in a random (and non-prioritized) order. Needless to say, it is allowed that the same project is written by more than one group. **If you, the students, have your own suggestions you can put forward these, and we can discuss them. There is, however, no guarantee that suggestions will be accepted**. In case you have your own suggestion you should send it, thoroughly prepared, to us, the supervisors, as quickly as possible.

1 Statistical analysis and forecasting of electricity prices

1.1 Motivation

This project consists of a number of proposals for the MATØK6 project: the idea of this project is to apply the theory and methods from time series to investigate the topics presented below.

A common theme is the statistical analysis of electricity prices. In particular, the study and the application of time-series models to electricity prices, and to their volatility. The most immediate application is forecasting.

More specifically, linear regression and autoregression models can be used to learn more about the relationship between different independent variables, the electricity prices and their lagged values. In a multivariate setting, the so-called vector autoregressive modeling (VAR) can be used: VAR modelling is based on the theories and methods from Time Series Analysis (one of the courses on the 6th semester), and to cut a long story short, VAR models may be described as vector versions of time series models for univariate time series. Moreover, it could be interesting to study and incorporate heteroskedasticity in the models; in other words, to consider the variance of data, and to account for a non-constant conditional variance.

1.2 Description of the project

Four concrete sub-proposals (**choose one of these for example**) in a non prioritized order:

- A structural VAR model of consumption of electricity and the price of electricity.
- A VAR model for the price of electricity, consumption of electricity, and the emission of CO2. Including analysis of the relation between electricity consumption and CO2 emission.
- AR, ARMA, ARIMA, Seasonal ARIMA models, and possible extensions, applied to electricity prices.
- Analysis of volatility. ARCH and GARCH models, and possible extensions, applied to electricity data.

1.3 Data

Data are available from *Nord Pool Spot* and *Energinet*.

The Nordic energy exchange, *Nord Pool Spot*, is owned by the Nordic and Baltic Transmission System Operators (TSO). *Energinet* is an independent Danish state owned company, that manages the Danish energy infrastructure.

In the electricity market *Elspot* is the auction market for *day-ahead* electricity delivery. The trading system enables the participants to submit their buy and sell orders for each hour during the coming 24 hour day. Orders are made between 8:00 AM and 12:00 PM, Central European Time (CET), and thus covers the coming 24 hours starting at 1:00 PM.

The aggregated buy- and sell-orders form the demand- and supply curves for each hour the next day. The intersection between the curves constitutes the so-called system price (per MWh) for each hour, and is thus the equilibrium price (if there were no so-called transmission restrictions in the electricity network).

Data may be downloaded from:
`https://www.energidataservice.dk/`
and / or
`https://www.nordpoolgroup.com/en/Market-data1/#/nordic/table`.

1.4 Literature

A selection of references:

- Cipra, T. (2021), Time Series in Economics and Finance, Springer-Verlag Cham 2021
- Kirchgässner, G., Wolters, J. (2007), Introduction to Modern Time Series Analysis, Springer-Verlag Berlin Heidelberg 2007
- Lütkepohl, H. (2005), New Introduction to Multiple Time Series Analysis, Springer-Verlag Berlin Heidelberg 2005
- Hendry, D. and Juselius, K. (2001): Explaining Cointegration Analysis, part II, The Energy Journal, Vol. 22, No. 1 (2001), pp. 75-120
- Liu, Y. and Roberts, M. C. and Sioshansi, R. (2018): *A vector autoregression weather model for electricity supply and demand modeling*, J. Mod. Power Syst. Clean Energy, (`https://doi.org/10.1007/s40565-017-0365-1`)
- Antonakakis, N. and Chatziantoniou, I. and Filis, G. (2019): *Energy Consumption, CO2 Emissions, and Economic Growth: A Moral Dilemma*, Munich Personal RePEc Archive, MPRA Paper No. 67422, (`https://mpra.ub.uni-muenchen.de/67422/`)
- Principper for elmarkedet, Energinet.dk. Available at (`www.energinet.dk`).
- Elmarkedet i Danmark, Energinet.dk. Available at (`www.energinet.dk`).
- Nord Pool Spot: Nordic Production Split 2004-2011
- Waldhauser, C. (2015): *Accessing APIs from R (and a little R programming)*, (`https://www.r-bloggers.com/accessing-apis-from-r-and-a-little-r-programming/`)
- Weron, R. (2014). Electricity price forecasting: A review of the state-of-the-art with a look into the future. International Journal of Forecasting, 30(4), 1030-1081.

In particular the last reference, Weron (2014), is a review of some of the current statistical approaches to electricity price forecasting. Section 3.8 therein could be a good start to find more related literature, and to have an overview of some time-series models which can be applied to electricity prices.