A STRUCTURAL MODEL TO ESTIMATE THE IMPACT OF HYDRO INFLOW ON SCANDINAVIAN POWER EXPORTS

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Overview

Hydro reservoirs in Scandinavian countries are increasingly considered to serve as a "battery" for the thermal-based system in Continental Europe due to their flexibility. In an interconnected system it is under some circumstances possible to replace expensive thermal capacity by cheaper hydro capacity. But the trading possibilities are dependent on the hydro inflow. Conversely the conventional thermal capacities in continental Europe may also provide back-up energy to the Scandinavian system in dry years. An improved understanding of the interdependencies between the Scandinavian trade balance, the hydro inflow and the continental power systems therefore provides an important basis for analysing possible future changes.

There are only few literature sources that investigate the trade between hydro-dominated areas and thermal-based areas like Scandinavia and Continental Europe. Existing papers focus on different aspects. Førsund (2011) develops a stylised equilibrium model of trade between hydro and thermal countries and compares this situation with autarky for both countries. Green,Vasilakos (2012) extend the model developed by Førsund (2011) and take a descriptive look at the data. Their focus lies on the influence of Danish wind power production on trade.

We expand these considerations by developing a structural model that explains the Scandinavian trade balance relating to inflow variations and test it on available monthly data. We find that already a parsimonious model provides a good econometric fit and the empirical findings are in line with the underlying theoretical considerations.

Methods

We develop a structural model to analyse the impact of hydro inflow and other fundamental factors on Scandinavian power exports. The basis is a stylised two-node power market model that takes into account the production of thermal power plants and the scarcity driven production of hydro reservoirs. Furthermore it incorporates the basics of interconnector economics (Vogel et al. (2012), Kirschen, Strbac (2004)).

We derive as a reduced specification for the trade balance of Scandinavia:

$$\bar{y}_{SC}(m) = ß_0 + ß_1 \cdot \Delta F_{SC}(m) + ß_2 \cdot \bar{D}_{SC}(m) + ß_3 \cdot \bar{D}(m) + ß_4 \cdot \bar{\lambda}_{SC}(m) + \varepsilon(m)$$

There $\bar{y}_{SC}(m)$ is the trade balace of Scandinavia SC in month m, $\Delta F_{SC}(m)$ the deviation from the median filling level of Scandinavian hydro reservoirs, $\bar{D}_{SC}(m)$ the demand in Scandinavia and $\bar{D}(m)$ the total demand in both areas. The typical seasonal patterns of varying water scarcity are captured through a water value $\bar{\lambda}_{SC}(m)$. As this is not directly observable, it is approximated by trigonometric functions.

We test this relationship between the Scandinavian trade balance and several explanatory variables using time series covering the period 2000-2012.

Results

The empirical findings validate the theoretical model. The preliminary results indicate that the relationship between the deviation from the median filling level and the Scandinavian trade balance is highly significant and also the other explanatory variables show the expected impact. Furthermore we test the specification against an extended model including quadratic terms which were suggested by the theoretical derivation. It turns out that these are insignificant so that the reduced model is adequate.

Conclusions

The paper provides insights into the relationship between the Scandinavian trade balance and hydro inflow. We develop a structural model based on a stylized power market model and test our implications with empirical data. The empirical results support the hypotheses derived from the theoretical model. The obtained results may be helpful in assessing the role of Scandinavian hydro reservoirs as flexibility providers for a continental European system

including large proportions of fluctuating renewables since the average export level determines the interconnector capacities available for flexibility provision.

References

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