Energy & Finance Christmas Workshop EFC18

Abstracts

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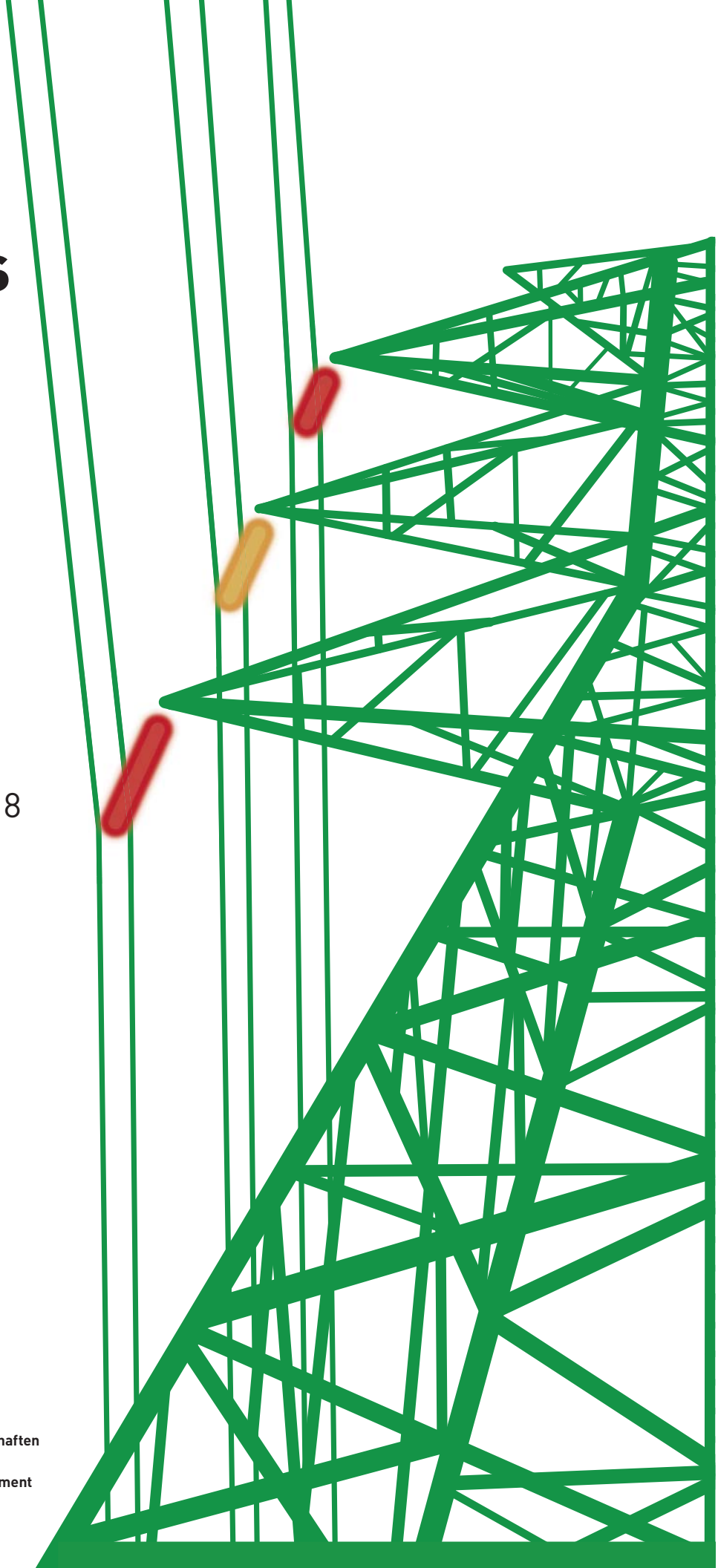

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TITLES AND ABSTRACTS

SESSION 1 – Modeling and Forecasting Electricity Prices

Matteo Pelagatti co-authored with A. Gianfreda and L.Parisio

Trends and Long-run Relations in Electricity Prices: Why Pre-Filtering Is Inevitable

Every scholar or analyst doing empirical research on electricity prices knows that their distributional and dynamic behaviour is extremely different from the one characterizing macroeconomic and financial data. Indeed, electricity prices are highly leptokurtic, often asymmetric and the low frequency components (i.e., the trend) are generally buried into high-variance noise, which reflects the complex structure of the cost of production (e.g., technological mixes, non-continuous production functions, power plant outages, etc.), discontinuities due to grid constraints and the operators' short-term strategies. However, a large number of empirical works on electricity prices does not take these features into consideration and apply standard least-squares/Gaussianity based econometric methods, thus, obtaining unreliable results. In this work we concentrate on testing for the presence of long-run components (i.e., trends) in scalar and vectoral time series that manifest the typical behaviour of electricity prices. Indeed, many authors support the hypothesis that electricity prices are mean-reverting because, when they apply unit-root tests, they reject the null hypothesis most of the times. Now, on a theoretical level it is hard to believe that electricity prices are not affected by gas, oil and coal prices, which are well known to behave like integrated processes; although recent empirical contributions have shown that RES are vanishing the nexus between fuel and electricity prices. When statistical results are in contradiction with theoretical considerations and common sense, a closer look at possible pitfalls in the used methods should be taken into account.

Arne Vogler co-authored with Florian Ziel

On the Evaluation of Multivariate Event Probability Predictions in Electricity Price Forecasting

Probabilistic forecasts are of ever increasing importance in the electricity price forecasting literature. They seek to predict the full conditional distribution of electricity prices and thus any statistical evaluation procedure aims at assessing the statistical validity of such distribution forecasts. Yet, as optimal statistical properties do not necessarily translate into optimal properties of a prediction in the sense of the problem to which it serves as an input, other evaluation techniques linked to the addressed problem have been considered in the literature. From such a practical perspective it may often be sufficient to specify a statistical event of interest, predict the associated probability and evaluate the quality of the prediction. As relevant events often depend on the entire price path in electricity price forecasting, they constitute multivariate events. We propose a framework to evaluate

predictions of multivariate event probabilities in electricity price forecasting, addressing the issue of evaluating problem-specific predictions with a statistically sound approach. The considered framework is illustrated using several events in the context of German day-ahead electricity prices, which have been chosen to represent typical considerations arising in the daily operation and optimization of generation assets and portfolios. Specifically, we forecast the probability of a given number of consecutive hours exhibiting negative prices, the probability of a pumped storage power plant being profitable during the day as well as the probability of the base-peak spread surpassing a predefined threshold. To forecast the associated probabilities expert models for electricity prices from the literature are estimated using a rolling window approach and simulated using a multivariate normal distribution, a multivariate t-distribution and a bootstrap approach. Across the ensemble of simulated paths of future electricity prices, we calculate the relative frequency of the considered event and report it as the predicted probability. The proposed evaluation framework allows for both the assessment of calibration of individual forecast models and also facilitates comparisons across different models. To assess the calibration of individual predictions the Seillier-Moiseiwitsch and Dawid calibration test for probability forecasts is considered. The Quadratic Probability Score in combination with the Diebold Mariano test is used to establish statistically significant differences in predictive ability between the considered model. To gain further insights about the sources of predictive deficiency the Murphy Decomposition of the Quadratic Probability Score is also examined. We conclude that the proposed expert models accurately predict probabilities of multivariate events related to the complete path of electricity prices and can be evaluated using the proposed framework. It thus offers a statistically sound and easily applicable compromise between a statistical evaluation of the full conditional predictive distribution and other methodologies based on the operational problem in consideration.

Daniela Escobar and Florentina Paraschiv

Identification of Distortion Functions in Energy Markets

Unlike classic financial markets, energy market prices are calculated by meeting the demand and supply curve, which nowadays is influenced by the presence of renewable energies. Renewable energies are dependent on weather and time of the day. All these uncertainties provide spot prices of seasonality, jumps and negative values. In addition, energy is non-storable and classic non-arbitrage theory does not apply in the valuation of future contracts. Moreover, these future prices sometimes price below the mean. In this work we propose to price future contracts by means of the distortion premium principle. With a switch regime model for the spot prices we simulate scenarios for underlying spot prices in different months of years 2008 to 2017. For these contracts we identify the risk behind the prices in terms of distortion densities, which are functions that change the baseline probabilities. We propose estimate the distortion densities as step and spline for different case studies. Finally, we provide a formulation for the risk premia in terms of distortion densities and insight in the sign and magnitude of the same.

Carlo Fezzi co-authored with Luca Mosetti

Size Matters: Estimation Sample Length and Electricity Price Forecasting Accuracy

Electricity price forecasting models are typically estimated via rolling windows, i.e. by using only the most recent observations. Nonetheless, the literature is silent on how to best determine the size of such windows. This paper shows that selecting the appropriate window prior to estimation dramatically improves forecasting performances. In addition, it proposes a simple two-step approach to determine the best performing models and window sizes. The value of this methodology is illustrated by analysing hourly datasets from two large power markets with a selection of ten different forecasting models. Incidentally, our empirical application reveals that simple models, such as the linear regression, can perform surprisingly well if estimated on extremely short samples.

Tomasz Serafin co-authored with Grzegorz Marcjasz and Rafal Weron

Selection of Calibration Windows for Point Forecasting of Day-Ahead Electricity Prices

We conduct an extensive empirical study on the selection of calibration windows for day-ahead electricity price forecasting, which involves six year-long datasets from three major power markets and four autoregressive expert models fitted either to raw or transformed prices. Since the variability of prediction errors across windows of different lengths and across datasets can be substantial, selecting ex-ante one window is risky. Instead, we argue that averaging forecasts across different calibration windows is a robust alternative and introduce a new, well-performing weighting scheme for averaging these forecasts.

Bartosz Uniejewski co-authored with Tomasz Serafin and Rafał Weron

Selection of Calibration Windows for Probabilistic Forecasting of Day-ahead Electricity Prices

We conduct an extensive empirical study on the selection of calibration windows for day-ahead electricity price forecasting, which involves six year-long datasets from three major power markets. We use Quantile Regression Averaging (QRA) across 7- to 365-day calibration windows and the best performing expert models to obtain probabilistic price forecasts. We also compare the univariate and multivariate setups for QRA with different numbers of predictors. Since the variability of prediction errors across windows of different lengths and across datasets can be substantial, selecting ex-ante one window is risky. Instead, we argue that averaging forecasts across different calibration windows is a robust alternative.

Florian Ziel

Determining the Demand Elasticity in a Wholesale Electricity Market

The main focus of researchers in energy markets is typically placed on the analysis of the supply side. The demand side, despite its critical importance, is a subject which still deserves a more profound academic investigation. In particular, the number of studies on the demand elasticity in a wholesale market is limited to merely several pieces.
In this paper we extend this field of study and propose a new method for determining the demand elasticity. More specifically, we decompose the data observed in the wholesale market into individual supply and demand schedules of the market participants. This allows us to better understand their bidding behaviour and thus make more precise inferences about the functioning of the electricity market.

Tiziano Vargiolu co-authored with Mariia Soloviova

Efficient Representation of Supply and Demand Curves on Day-Ahead Electricity Markets

Supply and demand curves on day-ahead electricity markets are the results of thousands of bid/ask entries in the day-ahead auction, this for all the 24 hours. In principle, it would be possible to represent, and forecast, these curves by taking into account each production/consumption unit as a separate time series, and then joining these together to construct the final curves, and thus the resulting price. However, the huge number of these units (from several hundreds to thousands) makes this naive strategy infeasible, unless one has extremely high computing capacity with complex machine learning algorithms available. In this talk, we present a much more parsimonious approach. In fact, the idea is to represent each curve using non-parametric mesh-free interpolation techniques, so that we can obtain an approximation of the original curve with far less parameters than the original one. The most promising technique to do so is the use of (integrals of) Radial Basis Functions (RBF), which are been used in several other applications (image reconstruction, medical imaging, geology, etc.) and allow a very flexible adaptation of the interpolating curves to real data. We will present different techniques for this interpolation, with their advantages and drawbacks, and with an application to the Italian day-ahead market.

Paolo Santucci de Magistris co-authored with Federico Carlini

Resuscitating the Co-Fractional Model of Granger (1986)

We study the theoretical properties of the model for fractional cointegration proposed by Granger (1986), namely the FVECMd;b. First, we derive a condition for the stability of the system in terms of the argument principle. Second, we prove that the model allows for a representation of the solution that demonstrates the fractional and co-fractional proper-

ties and we find a closed-form expression for the impulse response functions. Third, we prove that the model is identified for any combination of number of lags and cointegration rank, while still being able to generate polynomial co-fractionality. Finally, we prove that the asymptotic properties of the maximum likelihood estimator are analogous to those of the FCVARd;b model studied in Johansen and Nielsen (2012).

SESSION 4 – Solar Power

Takashi Kanamura

Volumetric Risk Hedging Strategies and Basis Risk Premium for Solar Power

This paper studies volumetric risk hedging strategies for solar power under incomplete market settings with a twofold proposal of temperature-based and solar power generation based models for solar power derivatives and discusses the basis risk arising from solar power volumetric risk hedge with temperature. Based on an indirect modeling of solar power generation using temperature and a direct modeling of solar power generation, we design two types of call options written on the accumulated non cooling degree days (ANCDDs) and the accumulated low solar power generation days (ALSPGDs), respectively, which can hedge cool summer volumetric risk more appropriately than those on well-known accumulated cooling degree days. Then we offer the pricing formulas of the two options under the good-deal bounds (GDBs) framework, which can consider incompleteness of solar power derivative markets. To calculate the option prices numerically, we derive the partial differential equations for the two options using the GDBs. Empirical studies using Czech solar power generation and Prague temperature estimate the parameters of two temperature-based and solar power generation-based models, respectively. We numerically calculate the call option prices on ANCDDs and ALSPGDs, respectively, as the upper and lower price boundaries using the finite difference methods. Results show that the risk premiums based on a solar power generation process are bigger than the risk premiums based on a temperature process. This is consistent with the fact that the power generation process approach takes into account more comprehensive risk than the temperature process approach, resulting in the bigger risk premiums for the power generation approach. We finally show that the basis risk premiums calculated by the subtractions of temperature-based option premiums from solar power generation-based option premiums increase in line with initial solar power generation. This may come from the fact that the increase of temperature causes both of the increase and decrease in solar power generation from the increase in solar radiation and decrease in solar panel efficiency, respectively, resulting in more uncertainty of the temperature's impact on solar power generation.

Johannes Mauritzen

Are Solar Panels Commodities? Evidence of Quality Differences and Asymmetric Information from California

Solar panels should not be considered commodities. Considerable quality differences, as measured directly by degradation of production over time, are found between manufacturers. This has implications for pricing and competition in the market for solar panel systems. I test two implications from the theory of asymmetric information of quality and find: 1.) Solar power systems with high-information third-party owners display higher quality than host-owned systems. 2.) Furthermore, with a 85% probability, the price of solar panels that are owned by high-information owners are more highly correlated to quality. I use random effects models estimated by maximum likelihood and hierarchical models estimated by Bayesian Markov Chain Monte-Carlo.

Fabian Siegel

DESERTEC – A Prospective Pillar for the German Electricity Market?

In the context of evermore arising effects of global warming, politics is motivated to find global strategies of how to face these problems. Also because of the resulting treaties, like the Paris Agreement, the German electricity market is finding itself in a phase of transition from conventional energy sources to renewable ones. In this regard, it is the task not only of politics but also of the private sector to find possible solutions of how to successfully accomplish this execution. This thesis seeks to elaborate the current structure of the German electricity market, in order to then see how Desertec or its underlying idea can be a possible solution for the arising problems in the process of transition. Therefore, it uses a linear regression model which helps to understand the different impact every energy source has on the electricity market. Afterwards, these impacts are regarded in the light of two Scenarios made by the German Aerospace Center (DLR), aiming to assure a 90 % share of Renewables on the electricity production. In order to further understand the idea of Desertec and its convenient characteristics for becoming an essential pillar of the future German electricity market, this thesis explains the functionality and feasibility of solar thermal energy imports, in the light of its underlying technologies, namely Concentrated Solar Power (CSP) stations and High Voltage Direct Current (HVDC) transmission lines.

Federico Clementi co-authored with Claudia Checchi

Natural Gas Consumption Elasticity and Meteorological Variables: A Micro-based Panel-data Study

High-frequency measurement of natural gas consumption has a paramount importance for several activities in the sector of gas distribution and, finally, for the well-functioning of the whole gas transport and distribution system. Although nowadays in several advanced countries many consumers are being provided with devices that allow for remote reading of consumption on a daily basis (called "smart meters"), a large part of them has not been covered yet. Natural gas consumption of these consumers is measured on a lower frequency (monthly or annually) and their daily consumption is computed using standard load profiles. This study aims at estimating the elasticity of thermal component of costumers' natural gas consumption to temperatures and other meteorological variables. The empirical analysis is based on a unique dataset of micro-data that combines daily measures of natural gas consumption of a sample of consumers provided with smart meters with local climate data.

Christoph Funk co-authored with Karol Kempa and Johannes Lips

Oil Price Shocks and the Cost of Debt in the Oil Industry – Empirical Analysis

The effects of oil price shocks on the world economy have been extensively studied over the last decade. Yet, little is known of the effects of these on the United States (US) oil industry on a firm level basis. We fill this gap by examining the relationship between (adverse) oil price shocks and the response of oil firms, the market for corporate loans and the impact on a firm's capital structure. In particular, we will give an answer to the question of how oil firms respond to oil-price shocks and how these shocks affect their borrowing decision and creditworthiness. We combine data on individual syndicated loans with data from corporate financial statements for an analysis of companies' financial decisions in great detail. First, we evaluate companies' borrowing behaviour and the loan characteristics, depending on the company's financial situation. Thereby, we gain insight in the relationship between an energy firms capital structure and their reaction to oil price shocks. Moreover, we differentiate companies along the oil industry's value chain. This allows us to determine the impact and exposure to price shocks depending on the position in the value chain. The overall findings of our research highlight the importance to monitor all financing channels of companies in order to be able to react to unforeseen deteriorations of market conditions.

Roberto Casarin co-authored with E. Ter Horst, G. Molina, R. Espinasa, R. Rigobon, C. Sucre
Network Analysis of World Oil Linkages

This manuscript proposes a new approach for unveiling existing linkages within the international oil market across multiple driving factors beyond production. A multi-layer, multi-country network is extracted through a novel Bayesian graphical vector autoregressive model, which allows for a more comprehensive, dynamic representation of the network linkages than traditional or static pairwise Granger-causal inference approaches. Building on the complementary strengths in Espinasa et. al. (2017) and Rousan (2018), the layers of the network include country- and region-specific oil production levels and rigs, both through simultaneous and lagged temporal dependences among key factors, while controlling for oil prices and a world economic activity index. The proposed approach extracts relationships across all variables through a dynamic, cross-regional network. This approach is highly scalable, and adjusts for time-evolving linkages. The model outcome is a set of time-varying graphical networks which unveil both static representations of world oil linkages and variations in micro-economic relationships both within and between oil producers. An example is provided, illustrating the evolution of intra- and inter-regional relationships for two major inter-connected oil producers: the United States, with a regional decomposition of its production and rig deployment, and Arabian Peninsula and key middle east producers, with a country-based decomposition of production and rig deployment, while controlling for oil prices and global economic indices. Production is less affected to concurrent changes in oil prices and the overall economy than rigs. However, production is a lagged driver for prices, rather than rigs, which indicates that the linkage between rigs and production may not be fully accounted for in the markets.

Rüdiger Kiesel
Carbon Risk in Credit Spreads

In this work we aim to analyse the effect of carbon risk measured in terms of emission certificate prices and carbon intensity on the creditworthiness of firms.

SESSION 6 – Hedging and Trading

Stein-Erik Fleten, co-authored with Joakim Dimoski, Sveinung Nersten, Nils Löhndorf
Dynamic Hedging for the Real Option Management of Electricity Storage

We model the risk management problem of an operator of electricity storage who participates in a wholesale electricity market and hedges risk by trading currency forwards as well as power futures contracts. Our model considers three types of risks: operational risk due to future supply uncertainty, exchange rate risk when operations and trading takes places in different currencies, and profit risks due to power price variability. We model the

problem as a multistage stochastic programming problem and propose a sequential solution approach to handle the high complexity of the optimization problem. Our contribution is three-fold: first, we show how currency risk and currency derivatives can be included in real option models of electricity storage; second, we introduce variables for accurate replication of the cash flow structure from a portfolio of financial contracts; and third, we compare optimization under a risk measure with simple hedging strategies often used in practice. For the case of a Norwegian hydropower producer, we quantify the reduction in risk through currency hedging when there is currency risk. We find that currency hedging leads to a moderate decrease of the profit risk, and that considering monthly power futures in the hedging strategy allows for precision hedging that can contribute to substantial reductions in risk.

Michael Schuerle and Florentina Paraschiv
Business Models for Power-to-gas: A Real Options Approach

Power-to-gas (P2G) is a technology that converts electrical power to gas fuels like methane, which can be stored and distributed via the natural gas grid. However, at present time the technology suffers from high specific investment costs, low efficiency and grid fees that must be paid if electricity is obtained from the power grid. On the other hand, P2G facilities are flexible consumers that may provide ancillary services or benefit from price fluctuations on the electricity spot market. We use a real options approach to assess the profitability of different operational concepts, given the uncertainties in future energy prices, exchange rates and investment costs.

Sjur Westgaard
Ten Commodity Trading Disaster that Shook the World

Trading commodities involves risk. Badly managed risk happens every day to individual traders who blow up their accounts with one overly aggressive or poorly controlled position, and it occasionally happens to those paid to manage other people's money as well. Often due to extreme leverage, periods of great success are quickly replaced by enormous losses and bankruptcy. In the commodity markets, that leverage is ever present as most trading is done via futures and option contracts. These positions can be long or short only, or it could be spread positions such as cross commodities like crude oil and heating oil, or cross calendar such as natural gas contracts with short and long maturities. As a result of the risk involved, some of the most spectacular blow-ups in trading history have involved commodities. In this study, we investigate the history of the 10 largest commodity losses (measured in 2007 dollars). We discuss what happen, why it did happen, and what can be done to prevent these type of events to happen again.

Katarzyna Maciejowska

Assessing the Impact of Renewable Energy Sources on the Electricity Price Level and Variability - A Quantile Regression Approach

The research on renewable energy sources (RES) indicates that an increase of the intermittent wind and solar generation would result in the fall of spot energy prices. At the same time, the literature is inconclusive about how the resulting changes in the generation mix impacts the price volatility Ketterer (2014), Rintamaki et al. (2017), Clo, Cataldi, Zoppoli (2015), Cludius et al.(2014). In this article, the influence of two types of RES (wind and solar generation) on the level and variability of German electricity spot prices is considered. The quantile regression models are built to estimate the merit order effect for different quantiles of electricity prices. The results indicate that both types of RES have similar, negative impact on the price level. When the price volatility, measured by the inter-quantile range (IQR), is considered, the outcomes show that wind and solar influence the prices differently. Conditional on the level of total demand, the wind generation would either increase (when the demand is low) or decrease (when the demand is high) the IQR. Meanwhile, the increase of solar power stabilizes the price variance for moderate demand level. Thus, policy supporting the development and integration of RES should search for a balance between the wind and solar power, which would be optimal under different demand levels.

Luca Rossini co-authored with Angelica Gianfreda and Francesco Ravazzolo

Further Developments About the Forecasting Performances of Linear Models for Electricity Prices with RES

This paper compares alternative univariate versus multivariate models, frequentist versus Bayesian autoregressive and vector autoregressive specifications for hourly day-ahead electricity prices, with and without renewable energy sources (RES). The accuracy of point and density forecasts are inspected in four main European markets (Germany, Denmark, Italy and Spain) characterized by different levels of renewable energy power generation. Our results show that the Bayesian VAR models with exogenous variables dominate other multivariate and univariate ones, in terms of both point and density forecasting.

Stefano Menna

From University to Trading Desk – Forecasting Models in a Real Trading Environment

From a cooperation between Unibz and Europe Energy, econometrics models have been developed in order to forecast day ahead electricity prices. I have applied them to my daily activities, testing their accuracy and working with the variables involved. Moreover, outputs were compared to real time market data with the aim of studying the existence of any signals useful for the development of trading strategies.

Carlo Lucheroni

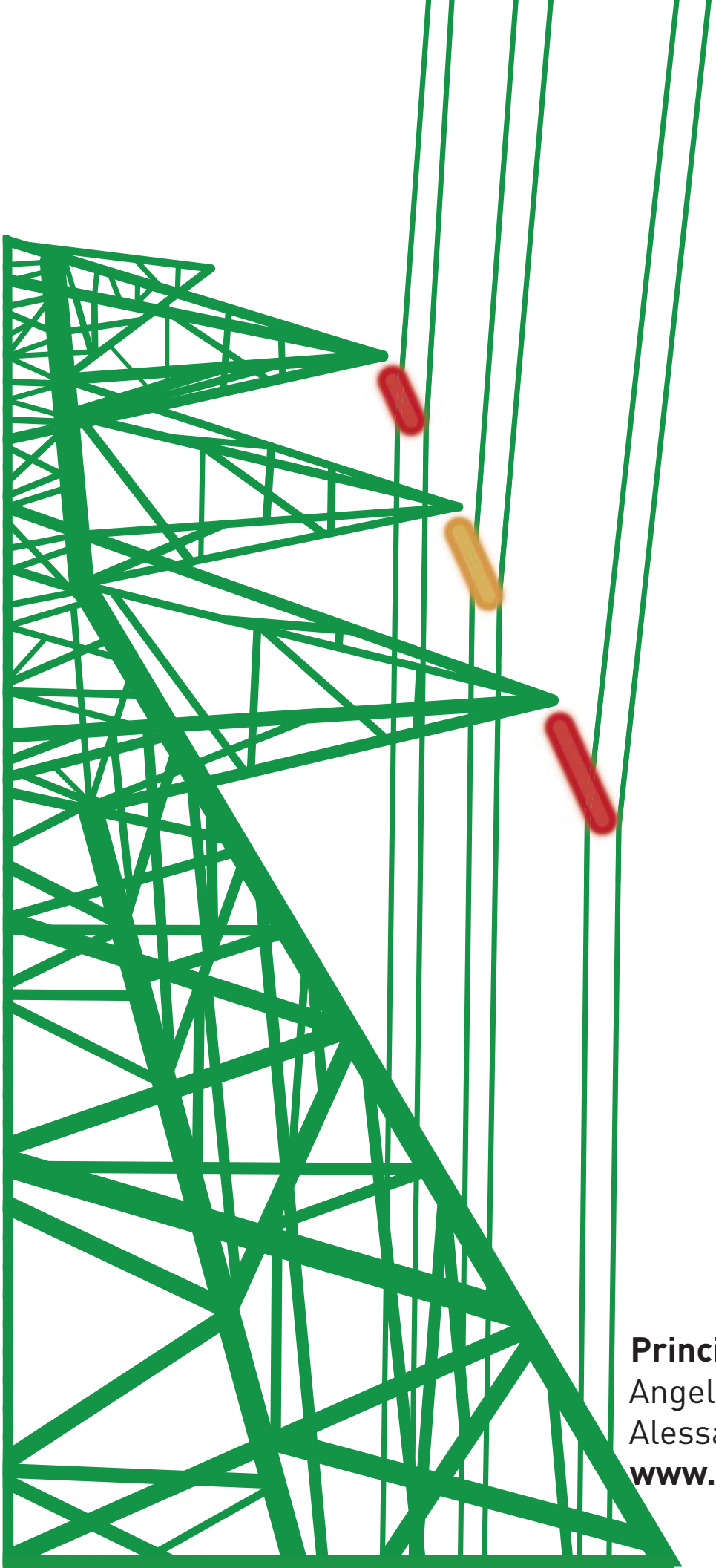
Machine Learning Approaches to DAM Price Series

Machine learning methods can help organize and forecast electricity market data, but they can be ineffective if used blindly and not adapted to the specificity of the problem. Two examples will be discussed, taken from both generative and discriminative modelling, to show how things can go wrong - and can be fixed.

Grzegorz Marcjasz co-authored with Rafal Weron

Artificial Neural Networks in EPF: Are Deep Structures Beneficial?

Deep Neural Networks are currently gaining popularity, with many seeing them as the state-of-the-art modelling and forecasting technique.Their effectiveness in the context of the day-ahead electricity price forecasting was also shown by some researchers. Here, the overview of possible approaches and the use of forecast improvement frameworks, such as Variance Stabilizing Transformations, are presented along with potential issues and results of limited testing on diverse data sets originating from the United States and Europe.



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