

## List of contributed speakers titles and abstracts

**Andresen, Arne** (HIST, Norway)

**Title: Modelling electricity forward prices using the multivariate normal inverse Gaussian distribution**

*Abstract:* This article presents a discrete random field model for forward prices driven by the multivariate normal inverse Gaussian (MNIG) distribution. The model captures both the idiosyncratic risk and heavy tails characterizing electricity forward prices. We fit the model to forward prices from the Nordic power exchange using a Markov Chain Monte Carlo algorithm. It is then compared to Gaussian based multifactor models in terms of goodness of fit to historical log returns. Our finding is that the proposed model offers a superior fit to the empirical distributions. Using the Fourier based approach to valuing options, we also calibrate the model to option prices and demonstrate that the model is able to fit both implied volatility smiles and skews. Sample European and barrier option prices are calculated under the proposed model and compared to prices obtained from a traditional Gaussian based model. (joint work with S. Koekebakker, S.E. Fleten and S. Westgaard)

**Fleten, Stein Erik** (NTNU, Norway)

**Title: Evaluation of static hedging strategies for hydropower producers in the Nordic market**

*Abstract:* In this paper we develop an optimization model to derive static hedging strategies for hydropower producers. We use this model to propose strategies with different risk characteristics. Previous research has primarily considered dynamic hedging strategies; however static hedging strategies are the common choice among practitioners because of their simplicity. Our contribution will therefore be to evaluate the usefulness of static hedging strategies for hydropower producers. The strategies are tested and compared with the natural hedging strategy, which means no hedging, on historical and predicted data. The results show that hedging with use of forward/future contracts significantly reduces the risk in terms of VaR, CVaR, and standard deviation of the revenue. Furthermore, this improvement results in just a minor reduction of the mean revenue. Our results imply that despite its simplicity, static hedging strategies are useful for hydropower producers in means of risk reduction at a small cost. (joint work with E., Bråthen and S.-E. Nissen-Meyer)

**Gronwald, Marc** (ifo Institute for Economic Research, Germany)

**Title: Evaluating Emission Trading as a Policy Tool - Evidence from Conditional Jump Models**

*Abstract:* This paper extends recent empirical research on European emission allowance prices (EUA) and evaluates emission trading as a policy measure. It applies two combined jump GARCH models and finds strong evidence of conditional jump behavior. This implies that EUA prices are subject to unexpected movements and that a considerable degree of uncertainty is present. According to the real option literature, uncertainty has adverse effects on the investment decisions. Thus, investment in abatement technologies and carbon savings are likely to be postponed due to the peculiar characteristics of emission allowance prices. Furthermore, this price behavior is at odds with the theoretical notion that emission prices equal marginal abatement costs. The findings of this paper are especially important with regard to European plans on extending and modifying the existing framework. (joint work with J. Ketterer)

**Gruell, Georg** (University of Ulm, Germany)

**Title: Pricing CO2 permits using approximation approaches**

*Abstract:* Both in a general deterministic and a stochastic framework it has been shown by Montgomery (1972), Rubin (1996) and Carmona et al. (2008) that emissions trading is the most cost-effective policy measure to reduce emissions. In theory prices are equal to the marginal abatement costs in a deterministic setting and equal to the discounted penalty times the probability that at compliance time total emissions exceed the number of permits issued by the regulator. Chesney and Taschini (2008) were the first to derive the price dynamics of emission allowances in a framework where the emission rate follows a geometric Brownian motion. However, they approximate the cumulated emission level by a random variable whose moments differ from the true ones. Using a moment matching approach we overcome this problem and derive the permit price dynamics. The investigation of the theoretical price properties and an intensive numerical study allow us to interpret the permit price in an even more convenient way and to give an explanation of the EUA permit price slump in 2006. (joint work with R. Kiesel)

**Hepperger, Peter** (Technical University Munich, Germany)

**Title: Electricity option pricing with Hilbert space valued jump diffusion models**

*Abstract:* In contrast to stock markets, the majority of contracts on the electricity market depend on the price during a future delivery period instead of a single point in time. Standard methods for pricing options (or rather swaptions) written on such underlyings therefore cannot be used without modification. Moreover, the relation of spot and forward prices is not clearly defined for electricity due to its non-storability. This difficulty can be avoided by directly modeling the forward curve under the risk neutral

measure, similar to the Heath-Jarrow-Morton approach for bond markets. Most models used in current literature for this purpose are special cases of Hilbert space valued jump-diffusion models. However, these pose some challenges when evaluating option prices, since the resulting distributions are not known in analytic form. One possible solution is lognormal approximation formulas, but these give very poor results in the presence of jumps. Numerical Monte Carlo simulations on the other hand are rather time consuming and converge slowly. We present an efficient numerical method, which is based on solving a Hilbert space valued partial integro-differential equation describing the swaption price. A Karhunen-Loève projection is used to reduce the infinite dimensional problem to a low dimensional one. This projection is related to an eigenvalue problem of a Hilbert-Schmidt operator. Convergence of the approximation can be shown with an error bound depending on the corresponding eigenvalues. Finally, we use a sparse grid finite difference method and discontinuous Galerkin timestepping to solve the reduced problem efficiently.

**Kanamura, Takashi** (J-Power, Japan)

***Title: A Classification Study of Carbon Assets into Commodities***

*Abstract:* This paper explores the classification of carbon assets generally considered as commodities by examining the characteristics of carbon prices. We propose a carbon price model reflecting the characteristics of the prices. The empirical studies using EUA (EU allowance) futures prices traded on the European Climate Exchange show that convenience yield of EUAs violates the property of commodities in terms of negative correlations between convenience yields of EUAs and EUA prices. It corresponds to the characteristics of the model we propose. Next, we examine mean reversion and seasonality of EUA futures prices often observed in commodity markets using AR(1) model with an annual sinusoidal trend. We show that EUA price analyses reject the existence of mean reversion and seasonality. We also examine the conditional correlations between EUA different delivery futures prices, resulting in almost positive correlations which may hold the same shape of the term structure as contango. In addition, the empirical studies using EUA option prices traded on the ECX show that carbon prices behave unlike commodities but like securities in terms of volatility smile. These empirical studies may support the counter argument to the classification of carbon assets into commodities.

**Kholodnyi, Valery A.** (Verbund Austrian Power, Austria)

***Title: Modeling Energy American Options in the Framework of the Non-Markovian Approach***

*Abstract:* We present and further develop the non-Markovian approach to modeling energy prices with spikes proposed earlier by the author. In contrast to other approaches, we model energy prices with spikes as a non-Markovian stochastic process that allows

for modeling spikes directly as self-reversing jumps. We use this approach to value American options on energy spots, forwards and swaps, one of the most popular types of energy options. The valuation is based on the semilinear evolution equation for American options and the multi-layered tree methods both introduced earlier by the author. We consider a practically important example of the crude oil American options and show that the extracted risk-neutral probability distributions allowed to conclude as early as at the end of March 2008 that the crude oil prices were at an upward spike and, due to the detected possible downward spikes, were highly likely to fall to the levels below \$40 dollars by the end of 2008, well before they even picked later that summer.

**De Maere d'Aertrycke, Gauthier** (Universite catholique de Louvain, CORE and INMA, Belgium)

**Title: The valuation of power futures based on optimal dispatch**

*Abstract:* The pricing of contingent claims in the wholesale power market is a controversial topic. Important challenges come from the non-storability of electricity and the number of parameters that impact the market. We propose an equilibrium model based on the fundamentals of power generation. In a perfect competitive market, spot electricity prices are determined by the marginal cost of producing the last unit of power. Electricity can be viewed as a derivative of demand, fuels prices and carbon emission price. We extend the Pirrong-Jermakayan model such as to incorporate the main factors driving the marginal cost and the non-linearities of electricity prices with respect to fuels prices. As in the Pirrong-Jermakayan framework, any contingent claims on power must satisfy a high dimensional PDE that embeds a market price of risk, as load is not a traded asset. Analyzing the specificity of the marginal cost in power market, we simplify the problem for evaluating power futures so that it becomes computationally tractable. We test our model on the German EEX for "German Month Futures" with maturity of June and September 2008. (joint work with Y. Smeers)

**Marckhoff, Jan** (University of Bamberg, Germany)

**Title: Jump Risk Premia in Short-Term Spread Options: Evidence from the German Electricity Market**

*Abstract:* This paper analyzes the valuation of day-ahead Physical Transmission Rights (PTRs) on the German-Dutch interconnector. From a financial perspective, PTRs are options written on the difference between the German and Dutch hourly electricity prices. We propose a model for the valuation of day-ahead PTR options incorporating the unique characteristics of the underlying spread. We empirically test our model for all PTRs between 2001 and 2008, where we model each hour of the day separately. Overall, especially for calm hours, our approach constitutes an adequate model for the valuation of day-ahead PTR options. Empirical results show a negative or zero market price of

jump risk for the turbulent hours 8 to 22. These results correspond to risk-loving or risk-neutral investors and indicate that market participants pay a premium for PTRs during peak hours. This premium is based either on increased hedging demand or on speculation. (joint work with M. Muck)

**Sgarra, Carlo** (Politecnico di Milano)

**Title: Some Remarks about the risk premium sign and risk-neutral pricing in electricity market models**

*Abstract:* In this paper we are going to provide a theoretical justification of the risk premium sign change on the basis of the most popular models available in the literature and of the most natural probability measure change: the Esscher Transform. In the framework of spot price dynamics described by Independent Increment processes we shall show that a measure change performed via the Esscher Transform can justify the sign change of the risk premium between short and longer maturities. (joint work with F. E. Benth)

**Stoll, Sven-Olaf** (EnBW, Germany)

**Title: A Spot Price Model for Natural Gas Considering Temperature As Exogenous Factor and Applications**

*Abstract:* The prices on natural gas spot markets exhibit a complex seasonality dependent on exogenous factors. The analysis of historical prices and temperature shows an important relation between price and temperature especially in longer periods of low temperature. We propose a model for natural gas spot prices under consideration of influencing variables derived from heating degree days. The stochastic dynamics of price and temperature is modelled by appropriate ARMA processes. Daily TTF day ahead and weekend prices are used for calibration. Two applications of this model are presented: valuation and hedging of gas storage by least squares monte carlo methods and pricing of full supply contracts for customers whose consumption strongly depends on temperature. (joint work with K. Wiebauer)

**Volmer, Thomas** (University of Bamberg, Germany)

**Title: A Robust Model of the Convenience Yield in the UK Natural Gas Market**

*Abstract:* specify a linear econometric model for the UK gas market which shows that, in addition to storage levels, temperature is strongly negatively related to convenience yield. We further present an extended linear model which provides support for a changing cost of physical storage in the spirit of Brennan (1958). We also test whether the smooth transition regime switching model by Goldfeld and Quandt (1972) is again more adequate

to deal with heteroskedastic residuals and a non-linear net storage cost function. Although this model does not perform as strongly as the other model specifications, it demonstrates explicitly that a prominent finding by Fama and French (1987) does not strictly apply to the gas market: Due to the capacity constraints of natural gas storage, which have been binding on the UK market in the past years, the variance of the futures basis increases rather than decreases with the storage levels. Finally we test and confirm the robustness of our single regime models in a forecasting exercise which identifies the extended linear model as the slightly superior specification.

**Westgaard, Sjur** (HIST, Norway)

*Title: Forecasting electricity spot prices at Nord Pool*

*Abstract:* The aim of this empirical study is to develop easily applicable models for forecasting monthly electricity spot prices at Nord Pool on a mid-term horizon. In liberalised auction markets accurate forecasts provide key information to practitioners, supporting decisions on bidding strategies, the engagement in bilateral contracts, production planning, derivatives pricing and risk management. Modelling and forecasting are done by means of Structural Time Series Models (STM). STMs are based on unobserved components, and allows for a stochastic treatment of the trend and seasonal component, as well as the sensitivities of external factors. According to our knowledge, no such study has yet been conducted on Nord Pool data. The data used for analysis covers the period from 2001 to 2009. Univariate models and various expansions with exogenous variables are investigated. Explanatory variables taken into consideration embody water reservoir level, import/export, load, temperature and the price of oil, coal and gas. Both the in-sample prediction power and 12 months out-of-sample forecasts for two hold-back periods are discussed. A Random Walk model is considered as a base comparator. We find that the best suited model is a univariate model consisting of a stochastic level, fixed slope and a fixed seasonal component. (joint work with N. Midtsund and H. Ueland)

**Wobben, Magnus** (University of Muenster, Germany)

*Title: Pricing electricity derivatives*

*Abstract:* The purpose of this paper is to develop a framework for pricing electricity derivatives. We do not - in contrast to most current approaches - focus exclusively on spot models which primarily reflect empirical spot price dynamics, but also ensure a straightforward applicability to the valuation of electricity derivatives. We show that a model with a jump and a spike component can be calibrated to both the time-series of spot prices and the cross-section of futures prices, once we allow for a seasonality of the jump and the spike parameters. Furthermore, we illustrate the importance of derivative pricing in electricity markets and present some examples of spot-options and options on

futures. We also discuss some regulatory issues for an efficient design of ancillary markets, such as markets for operating reserve or physical transmission rights. (joint work with N. Branger and O Reichmann)