Abstracts for the conference on "Energy and Commodity Risk Management and hedging of Commodity Derivatives"

Wolfgang Pauli Institute, Vienna

July 7-9, 2011

Invited speakers

Josef Bogensperger, Verbund

Title: *Practical aspects of risk management and the need for energy spot prices*

This presentation will give an overview of practical aspects of risk management in an energy environment. Products, performance measures and methods will be discussed and problematic areas discribed. Part of the presentation will be

- P & L
- Positions
- Var
- Par

Vladimir Bouchouev, Koch

Title: *The impact of hedgers and speculators on long-term oil prices*

Oil price spikes: fundamentals or speculation ? - Keynes theory of normal backwardation - Investors as macro-economic hedgers - Storage operators as risk absorbers - Modern theory of normal contango.

Alvaro Cartea, Madrid

Title: *Determinants of the forward premium in electricity markets*

This paper analyzes the driving forces behind the forward premium in electricity markets. The analysis is done in a two period model: in the first period speculators, producers and electricity retailers exchange forward contracts on electricity to be delivered in the second period. In this second period, retail

electricity demand is realized and this demand has to be fully met by retailers at a fixed (regulated) price. Retailers purchase electricity in the spot (wholesale) market open at that date. Electricity producers generate electricity to meet this demand for electricity in the spot market. Forward contracts between producers, retailers and speculators are settled in cash. We employ data of different markets to show what are the main drivers of the forward electricity premia. (with Jose Penalva, Eduardo Schwartz)

Alexander Eydeland, Morgan Stanley

Title: *Challenges and pitfalls of commodity modeling*

In this paper we will address some of the difficulties one faces while building models in commodity markets. We will analyze shortcomings of common modeling approaches and describe challenges these approaches have to confront to be useful in practice. We will give examples demonstrating divergence between theory and practice that frequently results in serious mispricing. Our objective is to make academics aware of the everyday practical issues to incorporate these issues in their future research.

Ben Hambly, Oxford

Titlte: *From bid stacks to swing options in electricity markets*

We develop a simple model for the formation of the spot electricity price. By modelling the cost of production of electricity from underlying fuels we derive the evolution of the bid stack and hence construct the spot price. We then investigate the pricing of derivatives such as swing options. We present dual approaches for the numerical pricing of these contracts.

Cyril de Jong, KYOS

Title: *Gas portfolio optimization: single asset approach versus a portfolio approach*

Gas portfolios of energy market players contain a mix of obligations and flexibilities. They consist of demand profiles, contracts with Take-or-Pay obligations, and transportation, LNG, storage and market trading options. It is therefore a challenge to determine the fair value, optimal use, and risk exposure of each portfolio component. One approach is to market each asset against the market, in the context of a specific trading strategy. This offers the possibility of a stochastic modeling framework and is especially relevant in liquid markets, such as NBP. The least-squares Monte Carlo methodology is especially powerful to apply this approach. However, when a liquid market is not available, or when there are clear portfolio interdependencies, a portfolio approach is required. In the presentation we will define a portfolio optimization. We will discuss the issues arising in an overall portfolio optimization, both within a deterministic and a stochastic framework. For the stochastic framework we will explain how

the modeling framework of dual stochastic dynamic programming (SDDP) can be implemented.

Rüdiger Kiesel, Essen

Title: *Market risk premium in power markets*

In this talk we provide frameworks to explain the market risk premium, defined as the difference between forward prices and spot forecasts. We show how it depends on the risk preferences of market players and what impact information differences may have. Our focus will be on an empirical investigation of the so-called information premium, which is defined as the influence of future information not incorporated in spot prices but taken into consideration when pricing forwards. We test for the existence of the premium using data from the German EEX at beginning of 2008 when CO2 certificates were introduced. Additionally, we will pro- vide an estimate of the value and an analysis of the properties of the information premium. (joint work with Fred Espen Benth and Richard Biegler-Koenig)

Andrea Roncoroni, Essec

Title: *Static hedging of multiplicative risk: theory and applications*

Corporate risk management aims at reducing exposure to market tradable and company-specific nontradable risk sources. We derive a variety of optimally structured insurance contracts on corporate positions affected by index, price, and quantity risk. Examples span agricultural, energy, and FX markets.

Esteban Tabak, New York

Titlte: *Physical and risk-free density estimation in the energy market*

(Joint work with Peter Laurence and Ricardo Pignol) This talk describes a new family of algorithms for probability density estimation, applied to time series for futures in the markets for gas and crude oil. The procedure works through fluid-like flows in the space of prices, with the actual observations playing the role of active Lagrangian markers that guide the flow through the maximization of their log-likelihood. The corresponding risk-free measure can also be estimated, by imposing the constraints provided by option prices and the martingale condition. These translate -through importance sampling- into local constraints on the flows.

Almut Veraart, London

Titlte: *Modelling energy spot prices by Lévy semistationary processes*

This paper introduces the class of Lévy semistationary (LSS) processes as a new framework for modelling energy spot prices. The main modelling idea consists

of four principles: First, deseasonalised spot prices are modelled directly in stationarity. Second, stochastic volatility is regarded as a key factor for modelling (energy) spot prices. Third, the model allows for the possibility of jumps and extreme spikes and, lastly, it features great flexibility in terms of modelling the dependence structure and the Samuelson effect. We provide a detailed analysis of the probabilistic properties of LSS processes and show how they can capture many stylised facts of energy markets. Further, we derive forward prices based on our new spot price models and discuss option pricing. An empirical example based on electricity spot prices from the EEX and on Henry Hub natural gas spot prices confirms the practical relevance of our new modelling framework. (This is joint work with Ole E. Barndorff-Nielsen (Aarhus) and Fred Espen Benth (Oslo).)

Rafal Weron, Wroclaw

Title: *Inference for Markov regime-switching models of electricity spot prices*

In this paper we discuss the calibration of models for electricity spot prices built on mean-reverting processes combined with Markov regime-switching (MRS). First, we propose an estimation method that greatly reduces the computational burden induced by the introduction of independent regimes and perform a simulation study to test its efficiency. Next, we construct a new goodness-of- fit testing scheme for the marginal distribution of regime-switching models. The test is based on the Kolmogorov-Smirnov supremum- distance statistic and the concept of the weighted empirical distribution function. While the existence of distinct regimes in electricity spot prices is generally unquestionable (due to the supply stack structure), the actual goodness-of-fit of the models requires statistical validation. We apply the new methods to sample series of electricity spot prices from the German EEX and Australian NSW markets. The proposed MRS models fit these datasets well and replicate the major stylized facts of electricity spot price dynamics.

Contributed speakers

Michael Coulon, Princeton

Title: *The Electricity Stack: Linking Fuel, Power and Emissions Markets*

The Electricity Stack: Linking Fuel, Power and Emissions Markets Structural models for electricity markets are becoming increasingly popular tools for understanding the complex dependence structure of energy markets. The shape and dynamics of the electricity bid stack is a key component of such an approach, which can realistically capture important effects such as merit order changes and fuel switching, crucial for example for the pricing of spread options and the valuation of physical assets. We propose an intuitive and tractable mathematical framework for the relationship between fuels (eg, coal and gas)

and power, justified by both a production cost argument and the observed bidding behavior of generators both in European and American markets. We then analyze the resulting dependence structure between the various energy prices (both spot and forward), and the implications for derivative pricing (including spread options) in these markets. The availability of closed form solutions for certain cases of the model is also discussed, as well as the extension of the model to power markets covered by cap and trade schemes for CO2 emissions. (Note: This work is not yet published but builds on some of the ideas developed in: Coulon & Howison, Stochastic Behaviour of the Electricity Bid Stack: From Fundamental Drivers to Power Price, JEM, 2009)

Stephan Ebbeler, Essen

Title: *Indifference Pricing of Weather Derivatives based on Electricity Futures*

The market of weather derivatives has gained an increasing interest in the last years. Most market participants use weather derivatives as a hedging instrument to cover the weather risks of their business (e.g. utility companies). In this paper we use the indifference pricing approach to derive prices for temperature derivatives (e.g. CAT futures) based on the more liquidly traded electricity future contracts. In order to apply the indifference pricing approach based on electricity futures we conduct an empirical study which verifies the strong correlation between the spot prices traded at the EEX and the temperatures in Germany. For this study we deseasonalize the temperature data as well as the EEX spot price data in order to obtain the two random processes driving temperature and spot price. The correlation is then calculated between these two deseasonalized processes separately for winter periods and summer periods. The results show that the correlation is significant for the winter period in each year, and for most of the summer periods as well. We further analyze that the correlation is also significant if we choose a geometric model for the EEX spot price instead of an arithmetic model. In order to derive closed form solutions for the temperature derivatives we use an Ornstein-Uhlenbeck process to model the dynamics of the spot price and a continuous version of an autoregressive model for the temperature dynamics. The derived indifference price of a CAT contract shows a risk premium which consists of two parts, a risk premium for hedging in electricity futures and a premium for the risk aversion towards trading CAT derivatives.

Markus Eriksson, Oslo

Title: *Swing Options in Markets with Jumps*

We set up a multidimensional linear price model multidimensional jump diffusions to study optimal exercise policies of swing options in commodity markets. From the model we formulate a stochastic control problem in continuous time, subject to an effective volume constraint. In the analysis of our model we show

that the usage of the option will lower its value. Furthermore, we derive necessary and sufficient conditions for the valuefunction. In addition we illustrate the results with examples and a numerical analysis, in particular for the electricity market. We also discuss the advantages of using a linear model for the price.

Heidar Eyjolfsson, Oslo

Title: *LSS processes as boundary solutions to hyperbolic spdes – numerics*

In this paper we will introduce a finite difference scheme to simulate solutions to a certain type of hyperbolic SPDE. These solutions can in turn estimate so called Levy semis- tationary processes, which is a class of processes that have been employed to model electricity forward and spot prices. We will see that our finite difference scheme converges to the solution of the SPDE as we take finer and finer partitions for our finite difference scheme in both time and space. Finally we will consider some examples from the energy finance literature.

Cristian Homescu, Wells Fargo Securities

Title: *Constructing volatility surfaces for commodities*

There are several practical reasons for having a smooth and well-behaved implied volatility surface (IVS): a) market makers quote options for strike-expiry pairs which are illiquid or not listed; b) pricing engines are calibrated against an observed IVS; c) risk managers use stress scenarios defined on the IVS to visualize and quantify the risk inherent to option portfolios. An IVS construction algorithm needs to address several potential issues, such as non- arbitrage in time/space, smoothness, stability under reasonable perturbations. Such procedures were successfully applied for markets such as equities, FX, rates, etc. However, many of those algorithms do not provide similarly good results for Commodities, due to characteristics of market data and other specific considerations for the commodity markets. We give an overview of various approaches for constructing IVS, including specialized interpolation methodologies, parametric or semi-parametric representations, or the use of formulas given by models (based on local and/or stochastic volatility, possibly extended to include jumps) to fit observed prices. We consider several such algorithms in the context of Commodities, and we present numerical results

Alfredo Ibanez, Madrid

Title: *The Optimal Method for Pricing Bermudan Options by Simulation*

Pricing of Bermudan options by simulation has attracted a lot of interest as many securities contain early-exercise-features and the underlying dynamics depend on several factors. In this regard, Longstaff and Schwartz (2001) develop a practical approach, which is based on least-squares and simulation. This paper introduce the optimal method for pricing Bermudan options by simulation

by extending Merton's (1973) approach for perpetual options – first deriving the option price for a given policy then optimizing between policies. The optimal method is easily implemented by least-squares and simulation. In the numerical exercise, it yields largest prices than any other method. By Alfredo Ibez (ESADE Business School) and Carlos Velasco (Department of Economics, Universidad Carlos III de Madrid)

Alexander Kulikov, Gazprom

Title: *Different approaches for defining risk contribution in energy markets*

Besides the task of risk measurement, the task of the allocation of risk between some parts of portfolio is also very important. This problem is closely connected with the problem of risk contribution. Also we give the solution for these problems in terms of multidimensional coherent risk measures. The multidimensional analogue of Tail V@R was introduced in [7] in the case of random cone of currency exchange rates. Also in [8] we consider NGD condition based on multidimensional coherent risk measures. The technique given is analogical to one considered in [3], and the sets of fair prices are much smaller than with using NA pricing (See [6]). Here we introduce examples when in multicurrency markets multidimensional coherent risk measures give more adequate result than one-dimensional ones for defining the fair currency exchange rate.

Nina Lange, Copenhagen

Title: *Seasonality in energy prices: Direct and hidden seasonality and the effect on option pricing.*

Energy prices exhibit seasonality. Miltersen (2003) suggest a way of incorporating seasonality by introducing a sine shaped parametrisation of the volatilities of the spot price and the future convenience yield. In addition, the initial term structure of future convenience yield needs to be parametrised. In this paper, we derive a condition under which the Miltersen (2003) can be rewritten into a Markov model, which gives a better estimation. We conclude that the initial term structure of future convenience yield matters much more than the seasonal volatility terms, when we estimate the model for UK gas prices. Further, the option price in this model is found and we discuss the seasonality estimations influence on the option price

Jukka Lempa, Oslo

Title: *A Merton problem of electricity markets*

In this talk we discuss portfolio optimization on electricity markets. The agents objective is to maximize her utility from final wealth when the investment is done on money and electricity forward markets. We study a class of forward curve models which admit a simple finite-dimensional realization. Using this, we recast the portfolio optimization problem as a finite dimensional control

problem and study its solvability. Furthermore, we discuss to which extent we can "reconstruct" an optimal infinite dimensional investment strategy from the solution of the finite dimensional portfolio optimization problem. We also make distinction between a purely speculative agent and an agent who is capable/willing to make the delivery and study the change in the optimal investment scheme caused by this distinction. Finally, we illustrate results with an explicit example. This talk is based on joint work with professor Fred Espen Benth from University of Oslo.

Thilo Meyer-Brandis, Munich

Title: *Consistent factor models for temperature markets*

We propose an approach for pricing and hedging weather derivatives based on including forward looking information about the temperature available to the market. This is achieved by modeling temperature forecasts by a finite dimensional factor model. Temperature dynamics are then inferred in the short end. In analogy to interest rate theory, we establish conditions which guarantee consistency of a factor model with the martingale dynamics of temperature forecasts. Finally, we consider a specific two-factor model and examine in more detail pricing and hedging of weather derivatives in this context.

Francesco Zirilli, Roma

Title: *The analysis of electric power prices using two models based on stochastic dynamical systems.*

Two models based on stochastic dynamical systems are used to study electric power prices. The first model is a multiscale stochastic volatility model introduced in [1] and further developed in [2]. The second model has been introduced in [3], [4] and is a model specifically designed to study spiky prices. These models are used to study time series of electric power prices. In particular we study a time series of electric spot prices taken from the U.S. market [2], and a time series of electric spot and forward prices taken from the U.K. market in the years 2004-2009, [5]. Using these sets of data and the maximum likelihood method the models are calibrated. The calibrated models are used to produce forecasts of electric power prices. The quality of the models and of the calibration procedure used is estab- lished comparing the forecasted prices with the prices actually observed on the real markets. A general reference to the work of the author and of his coauthors in mathematical finance is the website: http://www.econ.univpm.it/recchioni/finance