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A new active portfolio risk management for an electricity retailer based on a drawdown risk preference

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ABSTRACT

This paper addresses the deciding under uncertainty of an electricity retailer in order to maximise its total expected rate of return. The developed methodology is based on the modelling of the stochastic evolution of zonal prices that seeks to manage a portfolio of different contracts. Retailer's load and the price at each zone are forecasted using the seasonal autoregressive integrated moving average (SARIMA) model and a clustering technique is used for scenario reduction. Supply sources include the pool, self-production facilities, forward and bilateral contracts. The risk of cost fluctuation due to uncertainties is explicitly modelled using the multi-scenario drawdown methodology. This risk function quantifies in aggregated format the frequency and magnitude of the portfolio drawdowns over planning horizon. In-sample and out-of-sample runs are performed for a portfolio allocation problem. Carried out experimental results on the basis of realistic data, show that imposing risk constraints improve the “real” performance of a portfolio management in out-of-sample runs.

1. Introduction

1.1. Motivation

In a deregulated electricity market, Retailer participates in power markets by purchasing electricity via bilateral contracts with generating companies and from the electricity pool markets, and then sell it to their customers. Additionally, retailers have contracts with customers to supply their demand with the pre-agreed selling price. Consequently, retailers have a role of a mediator by signing the contract with both demand-side and supplier in the power markets.

As known, the objective of the retailers is the maximization of profit. However, the retailer should tackle with variable pool prices, demand forecast error, and the possibility of selecting a different supplier by the customers if the retailer cannot offer a competitive selling price [1]. Accordingly, risk modelling of these parameters is very essential for a retailer. Uncontrolled exposure to the risks could lead to devastating consequences, causing to lose substantial amounts of money that led to bankruptcy [2]. However, the electricity market is basically different from financial markets due to non-storability, semi-locally, seasonality pattern and distinct long-term and short-term volatilities. Efficient risk management requires the knowledge of financial theory and valuation of derivative contracts as well as the dynamics behind the parameters behaviour. In retailer risk management, research has mostly focused on extreme risks, such as “Conditional value-at-risk” (CVAR) measures. However, portfolios obtained by solving CVaR problems are fragile and unreliable. In this regard, our paper proposes a non-fragile model in which both the magnitude and duration of the portfolio losses are take into account using drawdown risk concept under uncertainty related to pool price, forward and bilateral contracting and client demand. An optimisation method is proposed for efficient computation of drawdown risk and active portfolio management [3].

1.2. Literature review

In the technical literature, several papers have addressed so far the perspective of the retailer. Reference [4] presents a two-level decision-making model using a matrix game for a distribution company (as retailer) in the day-ahead market where it has interruptible load and distribution generation options as additional resources. Reference [5] addresses the complementary problem of

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Nomenclatures

Sets

t, τ, θ	Set of periods
s	Set of scenarios
i	Set of trading contracts
j	Set of client groups
q	Set of power blocks in the forward contracts
d	Set of the generating blocks of the self-generating facility owned by the retailer

Parameters

T	Number of time periods
S	Number of scenarios
N	Number of trading contracts
J	Number of client groups
Q	Number of power blocks in the forward contracts
D	Number of production blocks of the generating facility
Δ_i	Time for each trading interval for contract ith
π_s	Probability of each scenario
$\rho_{i,t,s}$	Price of trading area i in tth trading interval and sth scenario
$\overline{P}^F_{i,q}$	Upper bound of the q-block of the forward contract i
$\overline{\lambda}^F_{i,q}$	Price of the q-block of the forward contract i
P_i^{Max}/P_i^{Min}	Maximum/Minimum trading limit for bilateral contract i
P_d^{Max}	Size of production block d
λ_d^G	Cost associated with block d of the self-generating facility
λ_i^B	The strike price of bilateral contract i
η	Congestion charge factor
$\lambda_{i,t,s}$	Price of trading contract i in tth trading interval and sth scenario
$r_{i,t,s}$	The ith asset's rate of return at time moment t and scenario s
$E^R_{j,t,s}$	Energy demand of client group j in period t and scenario s
$\mu^R_{t,j}$	Selling price of client group j in period t

Decision variables

x	Vector of portfolio positions
$W_{t,s}(x)$	Uncompounded cumulative rate of return of a portfolio at time t and scenario s
$P_{i,t,s}$	Traded power for contract i in tth trading interval and sth scenario
$P^P_{1,t,s}$	Procured power from the pool in tth trading interval and sth scenario
P_i^F	Power purchased from the forward contracting curve for contract i
$P^G_{d,t}$	Energy pertaining to block d of the self-generating facility at time t
P_i^B	Power purchased from the ith bilateral contract
κ_i^B	Binary variable that equals 1 if the bilateral contract i is exercised, else 0

functions

$\widehat{f}(x,t,s)$	Portfolio drawdown function at time t and scenario s
$\widehat{R}(x)$	Rate of portfolio return function
$\widehat{M}(x,s)$	Maximum drawdown function on scenario s
$\widehat{A}(x,s)$	Average drawdown function on scenario s
$\widehat{\Theta}_\alpha(x,s)$	Conditional drawdown function on scenario s
$\widehat{\omega}(x,\gamma)$	Risk-adjusted return function
$\widehat{C}(x)$	Cost trading function
$\widehat{J}(x)$	Revenue function

determining optimal pool bidding strategies for a retailer in the Nord Pool day-ahead market. Reference [6] seeks to minimise the expected cost of establishing forward contracts subject to various risk constraints using a stochastic optimisation approach.

References [7–9] propose a stochastic model to decide the amounts of power purchased from forward contracts and from the pool and to determine the optimal selling price to customers. In addition, strategies such as self-production facilities and call options are considered in Ref. [8]. Reference [9] has developed the idea presented in Ref. [7] by using a bi-level model in which the competition among rival retailers have been explicitly taken into account. Reference [10] proposes a model to set price changes and to encourage customers to shift their loads using time-of-use (TOU) rates.

Reference [11] proposes a short-term decision models for aggregators that sell electricity to prosumers and buy back surplus electricity in which the aggregator can control flexible energy units at the prosumers. The problem is a two-stage stochastic mixed integer linear program that includes the bidding process and bidding rules and handle the interrelations between hours. Reference [12] provides a risk management strategy for a retailer to deal with the uncertainties of the day-ahead market and how to hedge the financial losses in the market. A two-stage stochastic programming problem is formulated to establish the financial incentive-based demand response programs and the optimal dispatch of the distributed generation units and storages.

The authors in Ref. [13] demonstrated that the physical hedging which is supported by forward contracting and spot transactions can be an efficient approach to risk management in decentralized electricity markets. Reference [14] examines the dependence structure of electricity spot prices across regional markets in Australia based on a GARCH approach to model the marginal price series in the considered regions in combination with copulate to capture the dependence structure between the marginal. Reference [15] presents an electricity retail market model in which elastic demands of consumers in a distribution network are traded at flexible transactions selling prices offered by a retailer. In the transactions, the retailer offers a selling price for a unit time period over one day and the consumers elastically respond to the prices in which the transaction models as a Stackelberg game formulated by a bi-level programming problem.

In Ref. [16], an electricity retail market model is developed considering price risk of electricity retailer, called Capital Asset Pricing Model (CAPM). The CAPM is demonstrated to determine the retail electricity price for the end users while the retailer purchases electricity only from the pool market. The Risk Adjusted Recovery on Capital (RAROC) factor is used to quantify the price risk in the proposed model. Reference [17] proposes a multistage stochastic mean-variance optimisation model for the management of such a portfolio with two approximations: stage-aggregation and linear decision rules (LDR). The LDR approach consists of restricting the set of decision rules to those affine in the history of the random