Abstract

The paper discusses the basic principles for a comprehensive system of risk management in an electricity company. We consider roles played by the power exchange, and over-the-counter market. The solution is based on the advanced mathematical methods of the portfolio management, deriving from financial markets. The methodology includes sensitivity analysis (so called greeks) and widely applied risk measures (Value at Risk, Earnings at Risk, Cash Flow at Risk). The effective system of risk management on the Polish electricity market should be achieving the following goals: identification and measurement of the risk, pointing the tools for risk management, supporting the general strategy of the company, and increasing its value.

In addition we present software which may be helpful in learning the financial engineering methods, essential to manage risk in a competitive energy market. The software includes all regulations from the futures contracts market on the Polish Power Exchange, and it gives its users practical knowledge of hedging strategies and other techniques applicable to futures market.

1. INTRODUCTION

The extreme short-term volatility of electric power prices in a deregulated market provides the absolute need for performing risk assessment when trading energy. In the past few years researcher have quantified the short-term volatility and described it as a mean-reverting process. Although the discipline of the financing engineering has developed many techniques for financial markets including commodity markets, most of these techniques should not be simply applied to electric power markets because of the inherent differences between electricity and any other commodity. Real-time delivery coupled with the lack of real-time metering and the need to constantly balance supply and demand are among the reasons why these techniques must be adapted.

In this paper we introduce guidelines for a comprehensive system of risk management in an electricity company. The solution is based on the advanced mathematical methods of the portfolio management, including sensitivity analysis and downside risk measures.

2. METHODOLOGY

Risk management for an electric power company must involve the measurement of risk for all instruments or obligations owned by that company.

2.1. Sensitivity measures

We propose to use classical sensitivity measures, so called greeks. The most important two of them are Delta and Gamma. The Delta parameter ($\Delta$) is defined as the change in value of the derivative (e.g. option) with respect to the change of the underlying instrument (e.g. energy price). Mathematically, $\Delta = \frac{\partial C}{\partial U}$.
where $C$ is the price of derivative and $U$ is the price of underlying asset. So when you are analyzing a position, a Delta of 1 tells you that with the 5 PLN/MWh increase of the energy price, the value of the option will also increase by 5 PLN/MWh.

Since Delta is such an important factor, traders are also interested in how Delta changes. Gamma ($\Gamma$) measures the rate of change in the Delta for each increase in the underlying instrument. Mathematically, $\Gamma = \frac{\partial \Delta}{\partial U} = \frac{\partial^2 C}{\partial U^2}$. Gamma is a valuable tool in helping to forecast changes in the Delta of an option or an overall position. Delta and Gamma change constantly. The factors that affect Delta and Gamma are the same ones that affect an option's value including time, the price of the stock, and volatility.

The other three sensitivity parameters – Vega, Theta and Rho – measure the sensitivity of the option’s price to changes in implied volatility, time and interest rates, respectively. They are among the basic tools of risk management.

### 2.2. Hedging

When the Delta parameter of given portfolio equals zero, it means that the changes of underlying asset’s price will not affect the value of the derivative. This method of portfolio securing is called hedging, and the strategy of reducing portfolio’s Delta to zero is known as Delta-neutral.

The portfolio for which both Delta and Gamma are close to zero is even less sensitive to the changes of underlying instrument’s price. Such portfolio is called Delta-Gamma-neutral. Its construction is the next step in risk management.

### 2.3. Value at Risk

Value at Risk is a methodology developed by the financial industry to provide quantification for a company’s portfolio’s exposure to risk. It is the classic risk management tool widely used by financial institutions and corporate treasury functions in many industries. VaR measures the minimum occasional loss expected in a given portfolio within a stated time period.

**Example:** A one-day 95% VaR of 10,000 PLN means that the probability of single day loss greater than 10,000 PLN is lower than 5%.

There are many ways of calculating VaR. The variance-covariance method (also called Delta-normal) is one of the classic analytical methods. It is based on the assumption that the returns of instruments in portfolio are normal, which means that the returns of the whole portfolio are also normal with the variance equal to a mean weighted covariance of the instruments’ returns.

The method of historical simulation uses historical data to construct an empirical distribution of the portfolio returns. Historical returns are not analysed, only the hypothetical returns of given portfolio. They are calculated as if the market conditions in the next time would be similar to those in the recent period. Having calculated the empirical distributions of the returns, we can take as VaR the appropriate quantile of the distribution (usually 1% or 5%).

In the Monte Carlo simulation method we assume certain hypothetical model which describes best the behaviour of portfolio’s return rates. Then we generate several thousands of possible trajectories of the process of returns and calculate its distribution and quantiles for a stated moment in the future. Monte Carlo simulation method is the most powerful method of VaR calculation because it takes into consideration various risk sources as well as the time structure of returns and volatility.

Two variations on VaR have been developed in recent years: Cash Flow at Risk (CFaR) and Earnings at Risk (EaR). There are many variations on these techniques that individual vendors have created including Profit at Risk (PaR).

### 2.4. Earnings at Risk

For an operational business such as power generation, VaR may not be the single most useful metrics available. In these cases alternative risk metrics such as EaR and CFaR are more important.

Earnings at Risk measures the variability in accrued earning from physical deliveries made and financial positions that settle during the period. It does not include...
any change in the ongoing portfolio value after the risk time horizon as VaR does.

2.5. Cash Flow at Risk

VaR measures the potential loss of value of the present value of future cash flows for a defined time horizon. Cash Flow at Risk focuses on only a specific time period and measures changes in cash flow due to settlement of both physical and financial contracts within the period, but also incorporates the timing of cash flows to and from a participant such as when the settlement period and payment for a specific market or contract occurs.

CFaR is typically estimated using Monte Carlo simulation. However, there are important differences from the use of Monte Carlo simulation to estimate VaR. First, the time horizon is much longer in CFaR simulations. Second, the focus is on cash flows, not changes in mark-to-market values. And finally, the factors included in the simulation are not just the basic financial market factors included in VaR calculations, but any factors which affect operating cash flows.

3. TOOLS

To provide companies in the power industry in Poland with risk management tools, Polish Power Exchange and OTC market operators (e.g. poee) creates a series of derivative contracts fashioned to meet the particular regional needs and practices of the power industry. A sound and flexible financial market facilitates competition and encourages effectiveness of a power sector. Competition among power traders poses even greater demands for flexibility and efficiency. As a consequence, risk analysis is becoming an increasingly important tool in the power industry.

3.1. Financial Engineer

One of the first risk management tools specially tailored to the Polish Energy market has been developed jointly by companies from the power sector and academia. The Financial Engineer, based on earlier solutions for the financial market, offers all the necessary functionality for managing risk in the power market. The program computes and reports expected return and associated risk profiles for power or utility company’s portfolio of derivative contracts.

FIGURE 1. Financial Engineer

When you are facing the possibility of losing considerable amounts of money, it may prove difficult to manage the risk – and it may require a specialist to do it. Thanks to the user-friendly Financial Engineer, that specialist may be you.

3.2. Energy Derivatives Simulator

Energy Derivatives Simulator (EDS) is unique software, which simulates mechanisms of the Polish financial energy market. The program includes all regulations from the Futures Market on Polish Power Exchange. It enables to analyse a purchase portfolio at two parts of energy market: Day Ahead Market (RDN) and Over-The-Counter Market (OTC). The simulator is a professional tool helpful in learning financial engineering techniques needed by electric energy companies (suppliers, distributors and traders) to manage risk in a competitive energy market.

It is very easy to adjust parameters of the simulator to make it more useful and functional tool for a particular user, due to considerable elasticity of the software. The original solution implemented in the simulator introduces virtual players, which behave according to various, changeable strategies. The virtual players guarantee financial liquidity on the simulated market, when the number of human players is insufficient.
FIGURE 2. Energy Derivatives Simulator

For these reasons, EDS is an essential tool for beginner training in financial engineering. It gives users practical knowledge of hedging strategies and other techniques specific to the futures market.

4. REFERENCES


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