Optimal electricity generation portfolios
The impact of price spread modelling

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Abstract It is common practice to base investment decisions on price projections which are gained from simulations using price processes. The choice of the underlying process is crucial for the simulation outcome. For power plants the core question is the existence of stable long-term cointegration relations. Therefore we investigate the impacts of different ways to model price movements in a portfolio selection model for the German electricity market. Three different approaches of modelling fuel prices are compared: initially, all prices are modelled as correlated random walks. Thereafter the coal price is modelled as random walk. The gas price follows the coal price through a mean-reversion process. Lastly, all prices are modelled as mean reversion processes with correlated residuals. The prices of electricity base and peak futures are simulated using historical correlations with gas and coal prices. Yearly base and peak prices are transformed into an estimated price duration curve followed by the steps power plant dispatch, operational margin and net present value calculation and finally the portfolio selection. The analysis shows that the chosen price process assumptions have significant impacts on the resulting portfolio structure and the weights of individual technologies.

Keywords Portfolio theory · Decision making · Stochastic processes

Mathematics Subject Classification Primary 91G99; Secondary 91G60 · 91G10

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1 Introduction

Among the many different areas of interest which have been in the focus of energy-economical research in the last years, investment planning naturally takes a prominent role. On the one hand investment planning issues are of high relevance both from a social welfare and from a single investor’s perspective simply through their high capital intensity. On the other hand, their complexity gives much room for applying a wide range of methods, tools and instruments. This complexity usually forces investors to mask out the majority of influences which are relevant for the decision or to take them into account only in a strongly simplified form. The homogeneity of the product electricity implies that the profitability of an investment in generation capacity (in the case of thermal technologies) can almost exclusively be characterized as a function of the development of electricity, fuel and CO2 emission prices. Modern finance has established the practice to treat price developments as stochastic processes. The fundamental drivers of these processes are, if at all, only considered as the determinants of the parameters which rule these processes. This practice has also found widespread adoption in energy economics. The selection of suitable processes and their adequate parameterization thus determines the outcome and the quality of an investment decision. The relevance of an adequate parameterization is obvious and does not need further discussion. More interesting and, in a way, more alarming is that impacts of the underlying stochastic processes are often not clear at all.

Therefore, our study aims at examining the sensitivity of an investor’s decision to his choice of price process. We consider three different ways to model the long-term fuel prices several different processes and apply them to assess the returns of different investment options in a multi-stage process. Then, we analyze which are the corresponding optimal strategies for investors with varying risk aversion. In particular, we investigate the scale of variations between the different model approaches.

In the following part we give an overview of the relevant literature. The description of the different model stages follows in Sect. 3. After a brief presentation of our data in Sect. 4, we discuss our results in Sect. 5. We finish with our conclusion in Sect. 6.

2 Literature review

Even though the application of instruments and insights from the financial theory to energy markets has a long history, its application flourished with the market liberalisation in many countries in the 1990s. The focus on investment strategies and plant operation has since moved from a cost-based view to a returns based view. The optimization problem of cost-minimal load coverage has been replaced by return-maximizing plant dispatch with the electricity wholesale market as the main reference point. In the terminology of real option theory, power plants can be seen as physical options with the price spread between their input factors (fuel and possibly emission certificates) and their produced output (electricity) as underlying (Muche 2009; Weber 2007). Building a new plant can thus be interpreted as buying a (very long) sequence of spread options. The real option approach has been used in several works in the context of power plant investments, among others in Blyth et al. (2007), Fleten and Näsäkkälä (2010), Rothwell (2006), Westner and Madlener (2010, 2011a,b).