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The plunge in German electricity futures prices – Analysis using a parsimonious fundamental model

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HIGHLIGHTS

- We build a parsimonious fundamental model based on a piecewise linear bid stack.
- We use the model to investigate impact factors for the plunge in German futures prices.
- Largest impact by CO_2 price developments followed by demand and renewable feed-in.
- Power plant operating profits strongly affected by demand and renewables.
- We argue that stabilizing CO_2 emission prices could provide better market signals.

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ABSTRACT

The German market has seen a plunge in wholesale electricity prices from 2007 until 2014, with base futures prices dropping by more than 40%. This is frequently attributed to the unexpected high increase in renewable power generation. Using a parsimonious fundamental model, we determine the respective impact of supply and demand shocks on electricity futures prices. The used methodology is based on a piecewise linear approximation of the supply stack and time-varying price-inelastic demand. This parsimonious model is able to replicate electricity futures prices and discover non-linear dependencies in futures price formation. We show that emission prices have a higher impact on power prices than renewable penetration. Changes in renewables, demand and installed capacities turn out to be similarly important for explaining the decrease in operation margins of conventional power plants. We thus argue for the establishment of an independent authority to stabilize emission prices.

1. Introduction

Capacity planning in competitive electricity markets is a challenging task, particularly when no capacity markets are in place. Optimal decisions depend on directly observable factors, such as commodity prices and available power plant technologies, but also on uncertain and vague future prospects, such as political and socio-economic developments. German power plant operators have experienced this challenge at their expense. The large investment boom from 2006 to 2008 was followed by a nearly 40% drop in wholesale market prices. The prices of Phelix Base Year Futures contracts for 2014 with delivery in Germany were quoted at 61 EUR/MWh at the end of 2007 and dropped to almost 37 EUR/MWh by 2013 (cf. Fig. 1). Under the assumption of efficient markets, all available information and market participants' expectations are included in the futures market prices. Frequently, in the public and political debate, the futures price slide is attributed to the unexpected increase in renewable generation due to excessive subsidies.[1] The effect of increasing production from renewable energy sources (RES) on electricity market prices is discussed extensively in the academic literature by, among others, Rathmann (2007), Sensfuß et al. (2008) and Ketterer (2014) for the German market; Sáenz de Miera et al. (2008) for the Spanish market; and Jónsson et al., (2010) for the Danish Market. However, most of these works focus on implications for the spot price pattern, in general, without empirical verification of the theoretically derived results. In addition to the increasing RES, which essentially originated from the Renewable Energy Act, a number of political

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[1] Public and political debates on the electricity price slide in Europe have propagated this connection, e.g. in the German press: F.A.Z. Frankfurter Allgemeine Zeitung (2015); Schlandt (2014); Uken (2014).

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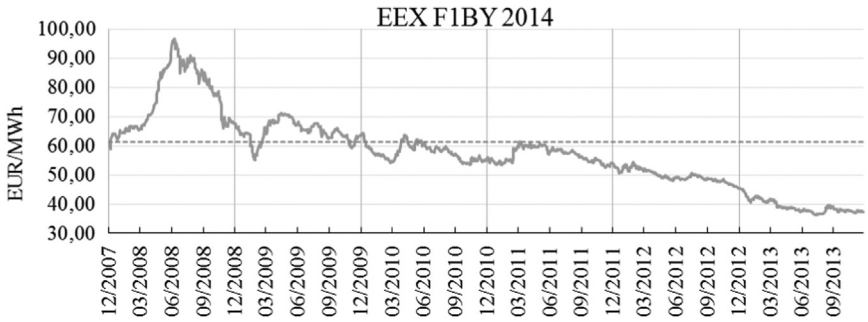

Fig. 1. Quarterly average price of Phelix Base Year Future Cal-14 from Q4 07 till Q4 13.

decisions are affecting the German energy market, notably the European Union Emissions Trading System (EU ETS) established in 2005 and the nuclear phase-out. The mandated phase-out is a result of decades of controversial public discussions and the events around the nuclear accident in Fukushima in 2011. Another relevant development in light of electricity price formation from 2007 to 2013 in Germany is the increasing efforts across Europe to advance international energy trading. The target is to harmonize European electricity prices and to reduce grid congestion through the use of market coupling, eventually flow based. The focus of the present paper is to investigate to what extent the unanticipated growth in renewable generation and other fundamental drivers explain the price drop in German electricity prices between 2007 and 2013. We thereby focus on electricity futures prices to abstract from the stochastics of actual realizations of renewable infeed and demand. An appropriate methodology for this purpose has to provide accurate forecasts of electricity futures prices based on market data and other publicly available information. A method that functions with only a parsimonious number of input parameters is favorable because it reduces the number of assumptions regarding market expectations and keeps the results interpretable. At the same time, such a parsimonious model may be used for further purposes, such as valuating derivatives, including power plant assets treated as real options.[2] The contribution of the article at hand is twofold. One part stems from a methodological perspective related to the developed parsimonious fundamental model while the second part answers to the formulated research questions: (I) It introduces a fundamental modeling approach that works with parsimonious assumptions and inputs by merging different approximations from the fundamental modeling context, particularly a piecewise linearization of the supply curve and approximation for unavailability and the foreign trade balance (FTB). (II) The model is used in a case study for Germany that presumably is the first systematic analysis of fundamental influences driving the drop in wholesale electricity markets prices between 2007 and 2014. In contrast to other recent works, we do not focus exclusively on the analysis of the effect of renewables; rather, we quantify the effect of several fundamental factors on the development of electricity prices. We show that contrarily to widespread belief, emission prices have a larger effect on power prices than renewable penetration. Assessing the operation margins of generation technologies, we show that the causes for the electricity price plunge and the drop in profitability of conventional generators are not equivalent. The article is structured as follows. Section 2 describes the modeling approach and its mathematical formulation. Section 3 describes the input data and the validation of the model. Section 4 uses the model to analyze the drop in wholesale electricity prices in Germany and discusses the results. Section 5 delivers a conclusion and an outlook for further research perspectives.

2. Methodology

2.1. Classification of the parsimonious model

Our modeling approach belongs to the general class of equilibrium models. We aim to model the prices as the results of a market mechanism that intercepts aggregate supply and demand functions. Fundamental information, e.g., power plant capacities, are incorporated to model the supply and demand side. The inclusion of such fundamental information is particularly advantageous when price developments over longer time spans are investigated. Additionally, the modeling of the supply curve accounts for non-linearities in the formation of energy prices, which is particularly relevant for electricity markets with a heterogeneous supply, such as in the German market. Classical, so-called *parameter-rich fundamental models* (cf. Weron, 2014) are based on a detailed representation of the supply stack and employ complex optimization routines. For example, Möst and Genoese (2009) Müsgens (2006) Weigt and Hirschhausen (2008) present applications for such models in the German electricity market but primarily focus on the identification of strategic behavior and price mark-ups. The major drawbacks of parameter-rich fundamental modeling approaches are a high complexity, a heavy computational burden and significant data requirements. In contrast, our methodology aims to avoid a detailed representation of the supply and demand and to find a reasonable approximation with only a parsimonious number of inputs and assumptions. Among other researchers, Carmona et al., (2012) refer to models that – with varying degree of detail and complexity – explicitly approximate the supply curve with the adjective 'structural'.[3] Within the class of *structural approaches* used to forecast electricity prices, different representations of the bid stack exist. One of the first examples is Barlow (2002), who uses a fixed parametric function. Later works consider dependencies of the bid stack, e.g., on available capacity (Burger et al., 2004) and on fuel prices, including emission costs (Aïd et al., 2009, 2013; Coulon and Howison, 2009; Carmona et al.,

[2] In this context, a related stream of research is the analysis of risk premia in electricity futures markets, e.g., Bessembinder and Lemmon (2002), Viehmann (2011), and Benth et al., (2008). Analyses about risk premia usually explicitly focus not on delivering price estimates but on reproducing and interpreting the price markups in futures prices that are attributable to the risk aversion of market participants. In this literature stream, the difference between fundamental price estimates and actual prices is interpreted as a risk premium. Considering the huge price changes observed in the market over the last decade, the focus of the present paper is on replicating these price changes as driven by fundamental factors rather than on estimating risk premia, which we believe to be an order of magnitude smaller than the fundamental price changes.

[3] Usually, fundamental modeling approaches work with the assumption that companies' bids are equal to the variable costs of power production. The bid curve is then represented by the ordered costs of production. In this sense, the term bid curve is synonymous to supply stack, supply curve or merit-order curve.