Energy Economics 31 (2009) 278–288

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneco

Market structure and the stability and volatility of electricity prices ☆

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ARTICLE INFO

Article history:
Received 2 October 2007
Received in revised form 4 November 2008
Accepted 4 November 2008
Available online 12 November 2008

JEL classification:
C14
C22
D43

Keywords:
Electricity prices
GARCH models
Lyapunov exponents
Market structure
Reconstructed dynamics
Stability
Volatility

ABSTRACT

By using a novel approach in this paper, (λ,σ^2)-analysis, we have found that electricity prices most of the time have increased in stability and decreased in volatility when the Nordic power market has expanded and the degree of competition has increased. That electricity prices at Nord Pool have been generated by a stochastic dynamic system that most often has become more stable during the step-wise integration of the Nordic power market means that this market is less sensitive to shocks after the integration process than it was before this process. This is good news.

1. Introduction

During the 1990s, the Nordic countries have gone through an extensive deregulation of their electricity sectors and, at the same time, there has been an evolution from national markets to a multinational electricity market. Thus, Denmark, Finland, Norway and Sweden have all reformed their electricity sectors and have today access to a common electricity market, which consists of two parts: (i) bilateral trade of contracts between operators; and (ii) the non-mandatory power exchange, Nord Pool.

The step-wise integration of the Nordic power market gives the opportunity to investigate several interesting questions that relate to the relationship between market structure and the behavior of electricity prices. First, because the aim of the deregulation and integration of the electricity sectors was to develop a competitive power market, which would benefit the consumers in the Nordic countries, one might ask whether the degree of competition has increased over time during this process? Bask et al. (2008) examine this question and also find that this, in fact, is the case.

What about the behavior of electricity prices? Has the increased competition at the Nordic power market affected the volatility of electricity prices in a systematic way? This issue is under scrutiny in this paper and using a data set that is similar to the one in Bask et al. (2008), we find that the volatility of electricity prices most often has decreased when the Nordic power market has expanded and the degree of competition has increased (see also Lundgren et al. (2008)). This finding is also consistent with the prediction of McLaren (1999) who presents an oligopoly model for a storable commodity such as water, which to a large extent is used in electricity generation in the Nord Pool area.

The main contribution in this paper is that we take a step further trying to figure out the reason for this change in volatility of electricity prices. Of course, the natural candidate is that the dynamics that govern the evolution of electricity prices have changed, but it could also be the case that the nature of the shocks hitting the Nordic power market has changed. A problem, however, is that we do not know the dynamics that govern the evolution of electricity prices, but as will be clear below (especially in Section 3), this problem is only apparent since we can reconstruct the dynamics using only electricity prices and, thereafter, measure the stability of the reconstructed dynamics.

☆ This paper has benefited from presentations at various conferences and seminars as well as from comments and suggestions by the editor and two anonymous referees. The usual disclaimer applies.

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0140-9883/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.eneco.2008.11.006

Concretely, what we do in this paper is to present (λ,σ^2)-analysis, which is a method to contrast the stability of a stochastic dynamic system (λ) with the volatility of a variable generated by this system (σ^2). Thus, if we focus on the development of Nord Pool, the method contrasts the stability of the dynamics that govern the evolution of electricity prices with the volatility of these prices. What we find is that the dynamic system generating electricity prices most often has increased in stability during the step-wise integration of the Nordic power market.

There are two dimensions of the findings in this paper. The first is theoretical. To the extent that approximating models of the energy sector are developed in an attempt to understand the behavior of energy prices and how they depend on the market structure, the stability of the dynamics that govern the evolution of energy prices should be added as an important dimension in which model and data should be matched. That is, our finding that electricity prices most of the time have increased in stability and decreased in volatility when the Nordic power market has expanded and the degree of competition has increased should be properties of a well-formulated model of the Nordic power market.

The second dimension is welfare. That electricity prices at Nord Pool most often have become more stable during the integration process means that the Nordic power market is less sensitive to shocks after this process than it was before it. This, however, does not mean that electricity prices never can change a lot from one day to the other, but it does mean that such large movements in prices are expected to happen less frequently. This is good news.

This is how the rest of this paper is organized: In Section 2, we first review the literature on the relationship between market structure and the price volatility for a storable commodity. Thereafter, we argue at an intuitive level why (λ,σ^2)-analysis is useful as a tool to contrast the stability of a stochastic dynamic system with the volatility of a variable generated by this system. In Section 3, we formally outline (λ,σ^2)-analysis and, in Section 4, we use this tool to investigate how the step-wise integration of the Nordic power market has affected the stability and volatility of electricity prices. Section 5 concludes the paper with a discussion.

2. Market structure and stability of prices

The aim of this section is to give a careful introduction to the subject of this paper, namely, the relationship between market structure and the stability and volatility of electricity prices. Therefore, in the first subsection, we review the literature on the relationship between market structure and the price volatility for a storable commodity. We do this to have a better idea of how the price volatility might be affected at a market with increased competition.

The second subsection is devoted to the relationship between the stability and volatility of prices or, more correctly, the relationship between the stability of a dynamic system and the volatility of prices generated by this system. We spend some time on this relationship since the techniques that we use to measure stability are not so well-known. Thus, what we do is to the give some intuition behind (λ,σ^2)-analysis that we formally outline in Section 3.

2.1. Market structure and volatility of prices

Since roughly one half of the electricity generated in the Nord Pool area is produced by hydro plants, it is natural to examine what the literature on storable commodities can offer regarding the relationship between market structure and the volatility of commodity prices. However, since most studies within this literature assume perfect competition (see Deaton and Laroque (1992, 1996) and Scheinkman and Schechtman (1983)), this relationship is far from fully understood.

One exception is McLaren (1999) who develops a model in which the price of the commodity decreases in volatility when the degree of competition increases. Specifically, McLaren (1999) presents a model of oligopolistic commodity speculation with an entry barrier in which the speculators perform non-cooperative storage in an infinite-horizon game. The author takes explicit care of the non-negative commodity stock constraint in the analysis and derives a Markov perfect equilibrium of the model in closed form.

McLaren (1999) emphasizes three properties of his model. First of all, there is less storage and more volatile prices than when the commodity market is competitive. Second, the oligopolistic equilibrium converges to the competitive equilibrium when the number of speculators becomes large. Third, an increase in the demand for the commodity lowers storage and increases the volatility of the commodity price.

Another paper is by Thille (2006) who, among other things, investigates the effect of storage on the price volatility under alternative market structures. Specifically, Thille (2006) presents a model of a duopoly in which the firms perform non-cooperative storage in an infinite-horizon game. A difference in this model compared to McLaren's (1999) model is that production no longer is exogenous. Thus, the firms in Thille's (2006) model have market power over both production and storage, and not only over storage as in McLaren's (1999) model. In the latter model, production is modelled as random harvests.

Using numerical analysis, Thille (2006) finds that the relative importance of demand and cost shocks determines whether the price volatility is higher or lower under imperfect competition than under perfect competition. The main findings are that when demand shocks dominate, the price volatility decreases when the degree of competition increases whereas when cost shocks dominate, the price volatility increases when the degree of competition increases. Thille (2006) looks at three market structures in the analysis: monopoly, duopoly and perfect competition.

An early paper that examines the relationship between the degree of competition and the price volatility for a storable commodity, which also should be mentioned, is Newbery (1984). In his random harvests model, the monopolist stores more than firms do in a competitive market, which results in a less volatile commodity price when the commodity demand is linear in the price. However, when the price elasticity of demand is constant, the commodity price is less volatile under competition. Thus, the findings are ambiguous as in Thille (2006). Since Newbery's (1984) model is a random harvests model, the firms have market power over storage only as in McLaren's (1999) model.

To summarize, the small theoretical literature that exists on the relationship between the degree of competition and the price volatility for a storable commodity does not give a unified answer. This should not come as a surprise since the models differ from each other in several respects (see Rui and Miranda (1996), Vedenov and Miranda (2001), and Williams and Wright (1991) for more literature on this topic). But what about the empirical literature? What does it say on the relationship between market structure and the price volatility for a storable commodity?

First of all, there are few empirical studies that measure the degree of market power in the Nord Pool area (see Hjalmarsson (2000) and Vassilopoulos (2003)) and almost none of them studies the effect of market expansion on the degree of market power. One exception, however, is Bask et al. (2008) who investigate how the degree of market power has evolved during the integration process at the Nordic power market using a conjectural variation method and they find that the degree of competition has increased when the common market has expanded. Unfortunately, we are not aware of any empirical study on the effects of market expansion on the degree of market power for some other power market than Nord Pool.