***Impact of variable renewable energy production on electricity prices through a modeling approach***

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**Overview**

The development of renewable energy sources (RES) is necessary to address global warming through the reduction of green-house gases emissions, and thus to achieve a sustainable development of our economies. In the electricity field, developing RES are mainly wind power and solar (mostly photovoltaic). Their development is now quite advanced in Europe, which has announced RES shares targets to be reached during the next decades: 20% by 2020 and 27% by 2030. However, these energies often need to be subsidized; otherwise they would not be competitive on electricity markets.

Moreover, this development challenges the design of current electricity markets. Indeed, these were originally designed to reflect the short-term costs of electricity production via the system marginal price, i.e. the marginal cost of the last unit needed to meet the demand. Marginal costs were traditionally driven by fuel costs, such as coal, gas, oil, or uranium. On the contrary, RES such as wind and photovoltaic have (almost) no marginal cost, and therefore tend to lower the spot price when they are producing. Furthermore, despite their (relative) predictability, wind and solar energies are intermittent (or variable). Thus, a developing share of such production sources is likely to add volatility to electricity prices. These two effects are also an issue for renewables themselves, since the current modifications of support schemes, and later their probable end, will face them more and more with the market, on which they will need to be profitable as well as other production units.

The aim of this study is to assess the impact of RES production on electricity prices, thanks to a Markov-Switching Model using wind and photovoltaic solar production data, and day-ahead spot electricity prices in Germany, with an hourly time step.

**Methods**

The literature on the modeling of electricity prices through econometric approaches is already quite large. Since electricity cannot be stored at a wholesale scale, electricity prices are highly volatile, with sudden peaks of very high or very low (even negative) prices. Thus, some studies chose to model the electricity prices using regime-switching models (Huisman and Mahieu, 2003; Janczura and Weron, 2010), while other electricity prices models are based on a General AutoRegregressive Conditional Heteroscedastic (GARCH) approach (Garcia et al., 2005; Liu and Shi, 2013). Recently, some analyses pointed out a significant impact of renewable electricity generation on market prices using these latter models (Li, 2015). However, although the elasticities of prices and volatility with respect to RES generation are respectively negative and positive, they are found to be generally quite low using these methods. This could be explained by the intermittency of the considered RES (wind and photovoltaic): they only have an impact on the market price when producing. Thus, in order to take into account the intermittency of the RES generation in the price modeling, we use a Markov-Switching Model, which is able to detect several regimes during which the impact of RES production is more or less important.

**Results**

The results show us that the RES generation has a negative impact on spot electricity prices and a positive one on the volatility (variance). The estimated coefficients of the proposed econometric model are higher (in absolute terms) than those obtained with models that do not take into account the intermittency of wind and solar productions. Indeed, these underestimate the impact of RES electricity production on prices, since most of the time there is little or no production at all. From this perspective, the Markov-Switching model is a satisfying alternative to the continuous modeling approaches.

**Conclusion**

We investigated the impact of renewable electricity production on electricity prices using a Markov-Switching Model. This econometric approach is different than previous ones in that it manages to focus on periods during which RES are effectively producing, thus leading to higher elasticities of the price than in continuous models such as ARMA-GARCH.

The two main effects of RES production is an average decrease of the price, and a higher volatility. These distortions affect directly the profitability of all production units and the incentive to invest in electricity production, and are thus an important issue to be addressed.

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