Understanding the determinants of electricity prices and the impact of the German Nuclear Moratorium in 2011

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Electricity is a homogeneous good that cannot be stored at reasonable economic costs. However, the demand is highly seasonal and needs to be satisfied at all times. Hence, it is most efficient to generate electricity with a mixture of various technologies with different properties regarding capital costs and marginal costs. These technologies also differ in terms of input fuels and carbon emissions.

Therefore, how input price variations affect the electricity price critically depends on the marginal technology used; and the marginal technology used depends on the level of the demand. The present paper tries to investigate exactly this effect. To illustrate the point, consider the "merit order", i.e., an ordering of fossil power plants from those with low marginal cost (like lignite or hard coal) to high marginal cost (natural gas). If the residual demand is low (e.g. because electricity demand is low in the night; or because there is a lot of wind feed-in), the marginal power plant will be a coal fired power plant, and we expect that changes in the gas price will not affect the electricity price. This will be the case only if demand is high. The approach in the present paper allows to identify how the fuel price effects vary with the size of the residual demand.

This is analyzed empirically using data from the German electricity market and applying a semiparametric cointegration model. In order to measure how the fuel price sensitivity changes throughout the merit order, it is necessary to use a model that allows the parameters of the fuel price sensitivity to vary freely. The semiparametric varying smooth coefficient model allows for straightforward analysis of the relationship between fuel price sensitivity and load. The main advantage of the model is that the nature of the varying effect is directly derived from the data, which means that there is no need for ad-hoc assumptions or restrictive functional specifications. Recent work shows that such a model can be used to estimate the nonlinear functional coefficients of a cointegration relationship. This method indicates a technology switch from coal to gas fueled power plants at around 60 gigawatt (GW) average non-wind daily peak generation.

The usefulness of this approach can be illustrated by analyzing a specific policy intervention like the German nuclear power suspension in March 2011. On Friday, 11 March 2011, a heavy earthquake and tsunami hit Japan and severely damaged the nuclear power plant in Fukushima. Following these disastrous events, the German government surprisingly decided to put a nuclear suspension in place. The decision for a moratorium of three months length was announced publically on the evening of Monday, 14 March 2011. The electricity futures traded at the EEX reacted with a steep price increase. Given an instant daily price increase of roughly 15%, the mere existence of a moratorium effect is obvious for the electricity futures. However, also the gas and carbon futures prices rose, probably because the market expected an increasing demand for fossil fuels, which are used to offset the suspended nuclear capacities. As a consequence, the event study focuses on analyzing the impact of the different influences that cause the electricity prices to rise.

In theory, there are two separate shifts of the merit order for the according electricity futures with delivery between March 2011 and June 2011. First, the supply curve is shifted left by about 6 GW, because nuclear generation capacity with low marginal costs is removed from the system. This effect is called the capacity effect of the moratorium. Second, the increased gas and carbon futures prices result in an upwards shift of the merit order.

On Monday, 14 March 2011, the first trading day after the Fukushima events, the prices of the electricity, gas and carbon futures rise. However, the capacity effect, which measures the abnormal price increase of electricity futures, shows no indication of previous information about the moratorium. There is no evidence for a capacity effect before 15 March 2011. Then, in direct response to the moratorium, all futures contracts immediately account for the shut capacity of about 6 GW. The market efficiently reacts to the moratorium by adding a capacity effect premium to the electricity price in order to reflect the missing generation capacity. In the following days, the capacity effect declines first, but remains at a rather stable level after this drop. This decline might have been caused by the fact that the market agents did not anticipate a nuclear moratorium and thus needed some time to develop sound forecasts. After a few trading days, the market agents expect that a part of the capacity effect will be mitigated by dynamic factors like the flexibility of the power plant portfolio or international transmission.

The framework also allows measuring the market's expectations for the time after the end of the moratorium in June 2011. For the quarterly future with delivery in Q3 2011, the development of the capacity effect reveals an unsteady reaction, which is lasting for a few trading days, before sound expectations have developed. Then, the market expects a capacity effect of roughly 3-4 GW for the time after the moratorium. The capacity effect for the following quarter is at a very similar level, but more stable over time. The yearly futures for 2012 and 2013 also reveal a more settled picture with a stable level of around 1 GW missing nuclear capacity. There are two possible explanations for this result: (1) that the moratorium of 6 GW has an expected capacity effect of only 1 GW in 2013 due to dynamic adjustment effects, or (2) that the market expects that the probability of an extension of the moratorium decreases with the time to maturity and is relatively low for 2012 or 2013. Generally, the capacity effect for futures with delivery during and directly after the moratorium is rather similar. Thus, there is an impact that is expected to be permanent and one can conclude that the market on average expected an extension of the moratorium with several nuclear power plants remaining closed down after the announced end in June 2011. This expectation proved to be correct as all affected nuclear power plants were permanently decommissioned after the end of the moratorium.