# *PRICE ELASTICITY OF DEMAND IN THE EUROPEAN WHOLESALE ELECTRICITY MARKET*

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## Overview

At the beginning of the year 2010, the wholesale electricity market in Germany experienced a remarkable institutional change. Since the year 2010 German transmission network operators (TNO) are required to trade energy produced under the German Renewable Energy Act feed-in tariff on spot markets, i.e. producers of renewable energy receive a fixed feed-in tariff for each kilowatt hour produced and network operators sell this electricity directly over the spot markets. At the same time, the market coupling in Central Western Europe was introduced. As a result, the marketing of renewable energy has a significant influence on price formation on wholesale electricity spot markets. This paper aims to quantify the price elasticity of electricity demand using data of the European Power Exchange (EPEX) day-ahead market for Germany and Austria. It contributes to the literature by using wind speed as an instrumental variable to deal with the endogeneity problems in a price-quantity model. Furthermore, empirical studies quantifying the price elasticity of demand in European wholesale markets are scarce as yet and to the authors' best knowledge, estimates do not exist for the EPEX' day-ahead market (Johnsen, 2001; Lijesen, 2007).

## Methods

In order to identify the causal effect of price changes on electricity demand, we make use of an instrumental variable for the independent variable price. The instrument has to fulfill the following constraints: it should be strongly correlated with the variable price and at the same time not directly related to the demand for electricity. We argue that wind speed is an appropriate instrumental variable, since it is exogenous and affects price via the supply side. Wind energy has the highest share of renewable energy sources in the considered market area and we therefore expect that it has a crucial effect on the market supply. However, our instrumental variable wind speed is only applicable from the year 2010. Until 2009 state-aided green electricity was traded by the TNOs over the counter. Hence, electricity from subsidized renewable energy sources did not affect the spot price directly. The amendment committed the TNOs to put the received electricity from the generators on the EPEX's day-ahead market. Since supply companies bought the electricity in advance, the residual demand load was cleared with the capacities on the stock exchange. After the amendment in the German Renewable Energy Act, electricity from renewable energy sources is provided at the spot market. This leads on the one hand to a shift in the supply curve and to the other hand to a "new" unbiased demand curve. From that moment we can clearly describe the relationship between the daily average wind speed in the market area and the day-ahead price for electricity. An increase in electricity generated from renewable energy sources leads, ceteris paribus, to a shift of the supply curve and changes therefore the "order" of the price determining power plant. This implies that we might observe low electricity prices on windy days and vice versa. Hence, we can use from 2010 the average daily wind speed in the market area as an instrumental variable for the average daily price to solve the identification problem of the demand function.

## Results

We conduct a two stage least square regression to obtain unbiased results for the estimate of the price elasticity of demand. Our model includes climatic variables and a several set of dummy variables to capture seasonal effects. In the first stage, we regress the price on the instrumental variable wind speed and on the other variables used in the initial regression. Table 1 provides estimation results of price elasticity of energy demand for the period from 2010 to 2012. This is the period in our data set where wind speed is a valid instrument for the endogenous variable energy price.

**Table 1:** Estimation results for the period from 2010 to 2012

| VARIABLES | (1)<br>log_price | (2)<br>log_vol | (3)<br>log_vol | (4)<br>log_vol | (5)<br>log_vol |
|---|---|---|---|---|---|
| log_price | | -0.808*** | -1.446*** | -0.994*** | -0.450*** |
| | | (0.117) | (0.0675) | (0.106) | (0.0930) |
| log_wind | -0.303*** | | | | |
| | (0.0220) | | | | |
| F-test wind | | 189.85*** | 51.84*** | 81.65*** | 130.81*** |
| log_temp | -3.056*** | -1.447*** | -4.764*** | -1.108* | -0.994*** |
| | (0.465) | (0.147) | (0.759) | (0.586) | (0.191) |
| log_sun | 0.00358 | 0.0168*** | 0.00894*** | 0.00347 | 0.00350 |
| | (0.00743) | (0.00536) | (0.00294) | (0.00211) | (0.00284) |
| weekend | -0.290*** | -0.313*** | -0.489*** | -0.330*** | -0.212*** |
| | (0.0130) | (0.0310) | (0.00708) | (0.0211) | (0.0320) |
| february | 0.0985*** | 0.0530*** | 0.0695*** | 0.00850*** | 0.0198 |
| | (0.0298) | (0.00538) | (0.0136) | (0.00262) | (0.0280) |
| [..] | [..] | [..] | [..] | [..] | [..] |
| december | 0.0710** | 0.0982 | 0.514*** | -0.0585** | -0.0543*** |
| | (0.0288) | (0.0668) | (0.0158) | (0.0263) | (0.00603) |
| year | | 0.0677*** | | | |
| | | (0.0257) | | | |
| Constant | 21.43*** | -111.6** | 45.40*** | 23.56*** | 20.73*** |
| | (2.602) | (50.61) | (4.338) | (2.981) | (0.993) |
| Observations | 1,093 | 1,093 | 365 | 364 | 364 |
| R-squared | 0.437 | | | | 0.103 |

In column one we report the results of the first stage regressions covering the whole period from 2010 to 2012. As we expected, the coefficient of wind speed is negative and highly significant. The estimated price elasticity of demand using every year the instrument is valid is about -0.81% implying a less price sensitive energy demand during the period from 2010 and 2012. Estimating separate price elasticities for each year yields to very interesting results. We observe a decreasing price elasticity of energy demand during the period from 2010 to 2012. The results are reported in column three, four and five, respectively. For the year 2010 we find a relative high price elasticity which is highly above one in magnitude. Estimation results for the year 2011 provide an isoelastic price elasticity of energy demand. Using only data from the year 2012, we find an even smaller price elasticity which is relative inelastic compared to the years 2010 and 2011. For each estimation result using wind speed as an instrument for energy price we report values of an F-test on the significance of our instrument variable in the first stage regressions. All reported F-test statistics are highly significant, implying that our instrument is relevant. During the weekend we find a lower energy demand in each of our regression results, which is in line with our expectations since less energy is needed.

## Conclusions

We have shown that wind speed is a useful instrumental variable for the time period from 2010 onwards, because the change in the German Renewable Energy Act makes the demand function identifiable. Our estimation results suggest that the price elasticity of demand from 2010 and 2012 is about -0.81% implying a less price responsiveness for a day-ahead wholesale market. Therefore, exercising market power by withholding capacities to influence the market price can be credible threat. Furthermore, we observed a decline of the price elasticity over the years. There might be two possible explanations. Starting from the supply side, the gradually increased quantity from renewable energy sources have led to several new market clearing events. The consumers take into account this import process with some time lag. From the other point of view, the demand side, one can argue that electricity demand became more inelastic due to economic upswing after the financial crisis 2008. The presented results are derived from average daily market information. A more sophisticated approach with hourly data is in progress which facilitates the estimation of the price elasticity of demand in peak and off-peak situations.

## References

Johnsen, T., 2001. Demand, generation and price in the Norwegian market for electric power. Energy Economics 23, 227-251.

Lijesen, M., 2007. The real-time price elasticity of electricity. Energy Economics 29, 249-258.