Competition in Germany's Minute Reserve Power Market: An Econometric Analysis

Justus Haucap, Ulrich Heimeshoff, and Dragan Jovanovic*
Heinrich-Heine-Universität Düsseldorf

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Abstract

On December 1, 2006 a major reform of the German Electricity Reserve Market took place. In response to low liquidity, low competitiveness, and high prices, the four distinct and time separated markets were synchronized on December 1, 2006 to one IT-based market. The main goal of the reform is to foster efficiency of the electricity reserve market in Germany. After two and a half years it is time to evaluate the performance of the new market design. We extend the analysis of the existing papers in two directions: In a first step, we test whether the interrelationship between markets changed using time series techniques. Furthermore, we created a unique dataset to apply panel data models to account for unobserved heterogeneity between regional markets. Additionally, we estimate causal effects by applying instrumental variable techniques. In contrast to other studies, in our paper the structural change caused by new market design is analyzed using panel data for the four transmission system operators in their respective control areas from April 1, 2006 to Mai 31, 2009. Furthermore, we analyze the relationship between minute reserve power and EEX spot-prices and control for endogeneity by using German weather data as instruments for EEX spot-market prices.

*Heinrich-Heine-Universität Düsseldorf, Düsseldorf Institute for Competition Economics (DICE), Universitätsstr. 1, 40225 Düsseldorf, Email: ulrich.heimeshoff@uni-duesseldorf.de.

1 Introduction

Due to the economical infeasibility of storing electricity, the balance between supply and demand has to be maintained at each point in time in the electricity grid. This constitutes one major task of the transmission system operator (TSO) whose responsibility is to maintain system stability by an appropriate procurement of balancing power. For theses purposes generation units are obliged to reserve some fraction of their capacity which can be used to eliminate frequency and load deviations in the grid. The imbalances between demand and supply can be caused either by stochastic fluctuations of reneweable energy sources, especially wind, and incorrect demand predicitions or breakdowns of generation units which inevitably lead to a decrease in supply of electricity and hence to a reduction of frequency and load in the grid. In addition to the wholesale electricity market the provision of ancillary services such as balancing power via the electricity reserve market is a crucial element for ensuring system stability.

Since December 1, 2006 the procurement of balancing power in Germany takes place on a common IT-based market. This new design was introduced as a result of the Energy Industry Act of July 7, 2006 (BNetzA, 2006). Previously, there were four distinct and time-separated electricity reserve markets where each TSO procured balancing power in its own control area using bilateral contracts with affiliated generation plants. Later, in 2001 and 2002 these bilateral contracts were replaced by procurement auctions which were prescribed by the German Federal Cartel Office while the markets remained distinct and time separated. In response to low efficiency and low liquidity of the electricity reserve markets a joint tendering platform (www.regelleistung.net) was introduced in December 1, 2006. The aim of this reform was to foster competition anf thus increase efficiency by supporting market entry especially through specified publication obligations and a reduction of the minimum quantity to be supplied. Furthermore, the prequalification procedure, the timing of auctions as well as the the selection of providers in merit orders has been specified and standardized. The crucial question which arises with respect to the reform is whether the implementation of the joint IT-platform stimulated competition and decreased prices in the minute reserve power market.

The related literature on this topic is currently rather scarce. Most papers which study the efficiency of the minute reserve power market in Germany approach the auction designs theoretically and focus on the possibility of strategic and collusive behavior (see e.g. Müller&Rammerstorfer, 2008, Swider, 2006&2007, Swider&Ellersdorfer, 2005). The other strand uses econometric analysis to evaluate the success of the market reform. Growitsch et al. (2008) test prices for both incremental and decremental minute reserve power for a structural break in their article while using time series data for the reserve power market and spot market. Their result is that the launch of the common IT-based platform had no significant effect on minute reserve power prices, i.e. no evidence for structural breaks. Another article focuses on the spread between positive minute reserve power prices and spot-market prices in order to derive implications for the market efficiency. Here, Growitsch&Weber (2008) apply a mean reversion model to test for the degree of integration between balancing power and spot market. They show that the market for minute reserve power has become more efficient due to the redesign while the spread increased at the same time.

We extend the analysis of these previous papers in two directions: We created a unique dataset to apply panel data models to account for unobserved heterogeneity between the four control areas. Furthermore, we extend the previous papers to estimate causal effects by applying instrumental variable techniques. In contrast to other studies, in our paper the structural change caused by new market design is analyzed using panel data for the four transmission system operators in their respective control areas from April 1, 2006 to Mai 31, 2009. It is tested whether the reform has led to higher integration between regional markets, i.e. to a significant reduction of the prices for minute reserve electricity. Furthermore, the relationship between minute reserve power and spot-market is analyzed. Finally, we control for endogeneity by using German wheather data as instruments for spot-market prices.

The remainder is structured as follows. Section 2 provides a brief overview of the German minute reserve market and the auction mechanism from a theoretical perspective. In section 3.1 the data set and relevant descreptive statistics are presented. The following section 3.2 deals with the econometric analysis in several steps. Section 4 concludes.

2 The German Minute Reserve Power Market

In order to maintain system stability by balancing demand and supply of electricity at each point in time a balancing power system is needed for which TSOs are responsible. Thus they have the duty to balance frequency and load in the electricity grid so that the transmission system does not collapse. In Germany there are four TSOs each responsible for one of the four control areas. To comply with the aim of maintaining system stability they have to procure balancing power over reserve power markets.

Depending on whether the difference between the actual demand and supply for electricity is positive or negative two kinds of reserve electricity can be distinguished. If the actual demand exceeds the 'feed in' along the transmission network, then positive or incremental reserve power is needed to restore the balance. Whereas negative or decremental reserve power must be used if more electricity is produced than consumed, i.e. supply exceeds demand. In this case the TSOs are obliged to sell excess electricity over the reserve power market. According to the Union for Co-ordination of Transmission of Electricity (UCTE) in Europe the balancing process occurs in three so-called control levels which differ by time frame and the needed amount of capacity. Hence, three kinds of reserve power exist which differ with respect to their quality: primary, secondary and tertiary control. Our paper strictly focusses on tertiary control, i.e. minute reserve power, which has the lowest quality among the three. Further technical details are presented in UCTE (2004).

Since December 1, 2006 the four German TSOs jointly procure minute reserve power on an IT-based paltform (www.regelleistung.net). Following Müller & Rammerstorfer (2008) the redesigned auction mechanism can be characterized as a (i) repeated, (ii) day-ahead, (iii) multi-unit, (iv) one-sided, (v) multi-part and (vi) pay-as-bid auction. The auction takes place each weekday for the next day and it is timed before the spot market. The main modifications of the market design concern the synchronization of the tendering in time and place, i.e. the four TSOs simultaneously procure minute reserve power on the same IT-based platform right before the spot market. From a policy point of view these main changes should facilitate market entry by new generating plants and thus promote competetion leading to lower prices for both incremental and decremental minute reserve power. But this development cannot be confirmed from a theoretical perspective. It remains rather unclear whether the prices should increase or decrease due to the reform of December 1, 2006 (Müller & Rammerstorfer, 2008).

Whether this political goal was achieved is examined in our paper. Empirical evidence derived from dynamic panel data models targeting to answer this question is provided in the next section.

3 Econometric Analysis

3.1 Data Set and Descriptive Statistics

A unique panel data set is used based on daily prices for minute reserve power in Germany from January 1, 2006 to May 31, 2009. The prices are calculated as weighted mean values for each TSO (EnBW, E.ON, RWE and Vattenfall) separately. The focus is on both kinds of minute reserve power, namely, incremental and decremental power. In addition oil, coal and gas prices as well as the the daily 'feed in' from wind power in Germany for each control area are incorporated in our study as control variables. To get a better insight whether the reform had an effect on incremental and decremental minute reserve power prices the data is devided into two periods. The first period lasts from January 1 until November 30, 2006 and thus reflects the time when the market design was not reformed. The second period comprises the time from December 1, 2006 until May 31, 2009. Hence, it describes the price development after the implementation of the common web-based tendering platform. The following table shows the most important descreptive statistics of the considered time series.

Table 1: Descriptive statistics of incremental MRP prices

	Period 1					Period 2				
	Obs	Mean	SD	Min	Max	Obs	Mean	SD	Min	Max
ENBW	334	86.97	92.76	19	520.7	913	31.63	60.94	.78	750.1
EON	334	87.44	91.90	18.47	508.36	913	24.94	36.60	2.02	251.92
RWE	334	86.91	96.84	17.72	551.11	913	28.40	44.49	2.07	361.42
Vat	334	92.94	99.59	18.82	519.97	913	26.42	40.05	2.05	304.6

It can be easily seen that on average the prices for incremental MRP are lower in each control area after the reform. The same is true for the volatility. Figure 1 shows the price developments for each control area separately. The dashed red line represents the date of the reform. It can be seen that the relationship between the control areas is relatively high in both periods.

Figure 1: Development of incremental MRP prices in each control area

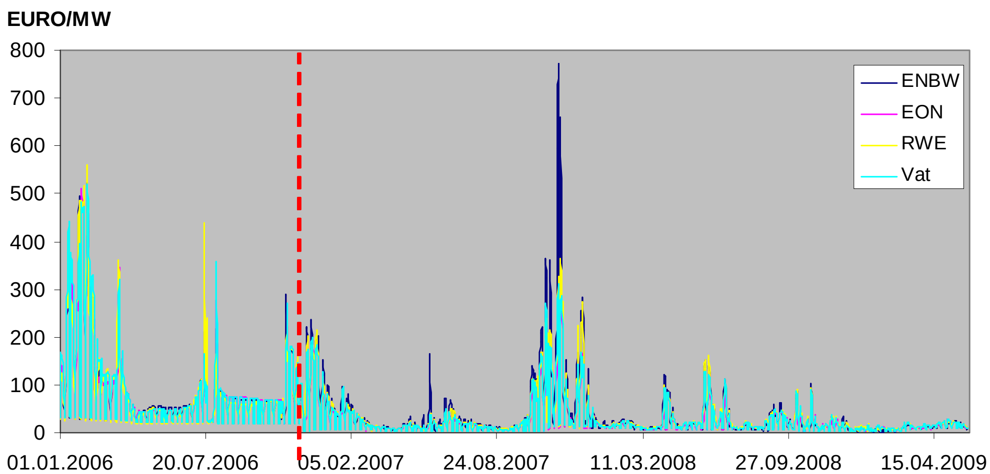


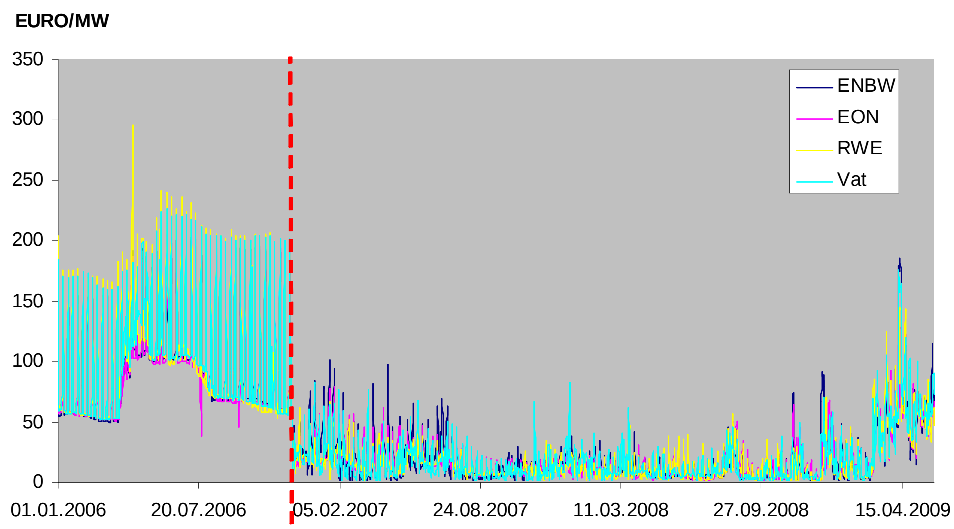
Table 2 and Figure 2 show the same figures for decremental MRP. It can be stated that both average prices and volatility decreased considerably after the launch of the common IT-based platform.

Table 2: Descriptive statistics of decremental MRP prices

	Period 1					Period 2				
	Obs	**Mean**	**SD**	**Min**	**Max**	**Obs**	**Mean**	**SD**	**Min**	**Max**
ENBW	334	94.37	41.98	49.42	206.03	913	19.38	22.25	.1	185.05
EON	334	92.61	41.39	38.79	204.23	913	18.01	18.15	.38	128.75
RWE	334	100.07	50.45	52.4	292.33	913	17.92	19.18	.41	145.08
Vat	334	99.90	47.72	52.05	226.81	913	18.78	21.24	.35	173.98

In contrast to figure 1 which does not clearly reflect the implications provided by the descreptive figures in table 1, the price developments in figure 2 indicate a clear decrease of decremental MRP average prices immediately after the reform. In addition a positiv relationship between the control areas can also be recognized.

Figure 2: Development of decremental MRP prices in each control area



It should be clear that the above presented descreptive statistics do not provide any implications in terms of causality. They rather indicate tendencies and correlations. The econometric analysis is presented in the next section where panel data models in conjunction with instrument variable techniques are applied.

3.2 Interrelationship between Regional Minute Power Reserve Markets

To investigate whether the interrelationship between the four regional markets changed due to the reform of the German Electricity Reserve Market, we construct a Vector Autoregressive Model (VAR) to test if there are relationships between the regional markets. We estimate a VAR-model of the folowing form:

$$y_t = A_1 y_{t-1} + ... + A_4 y_{t-4} + t + u_t.$$

In our basic VAR-model $y_t = (y_{1t}, ..., y_{4t})'$ is a vector of four observable endogenous variables, the observed prices on regional reserve markets, and t is a deterministic linear time trend. The term u_t is a standard unobservable white noise process with zero mean and A_i is a parameter matrix (Hamilton, 1994: 257-258). The VAR-system is estimated by feasible generalized least squares. Based on our estimations, we perform Granger-causality-tests to check whether the price series of the regional operators influence each other as a measure of interrelationship. Granger-causality exists if a variable y_{2t} helps to improve forecasting another variable y_{1t} (Lütkepohl, 2005: 41-43). So Granger-noncausality can be expressed as

$$y_{1,t+h|\Omega_t} = y_{1,t+h|\Omega_t \setminus \{y_{2,s}|s \leq t\}}.$$

The series of the variable y_{2t} is not Granger-causal to y_{1t} if removing past information of y_{2t} from the information set has no effects on the optimal forecast of y_{1t}. Instead Granger-causality exists if the equation holds for at least one step h (see Lütkepohl, 2004: 144). To avoid spurious regressions, we first have to check whether the subscriber series of the competitors are stationary. Before estimating VAR models, it is very important to analyze the time series properties of the series used in the analysis because regressions of non stationary time series on each other usually suffer serious spurious regressions problems. Taking account of these problems one usually applies unit root tests. In our case it is important to test on unit roots and structural breaks jointly, because it is reasonable that changes in regulatory environments cause structural breaks in our time series. To get statistically robust results, we apply unit root tests which additionally take account of the structural break in the series. We apply the one break version of a unit root test developed by Clemente, Montanes, and Reyes (1998). The procedure to apply the Clemente, Montanes, and Reyes-methodology for two structural breaks starts with the estimation of the following regression:

$$y_t = \mu + \delta_1 DU_{1t} + \delta_2 DU_{2t} + v_t.$$

In this regression $DU_{mt} = 1$ for $t > T_{bm}$ and 0 otherwise, for $m = 1, 2$. T_{b_1} and T_{b2} are the breakpoints. The residuals obtained from this regression v_t are the dependent variables in the next equation to be estimated. They have to be regressed on their lagged values, a number of lagged differences and a set of dummy variables, which is needed to make the distribution of the test statistic tractable (see Baum (2001) for a detailled discussion):

$$v_t = \sum \varpi_{1i} DT_{b1,t-i} + \sum \varpi_{2i} DT_{b2,t-i} + \alpha v_{t-i} + \sum \theta_i \Delta v_{t-i} + e_t.$$

$DT_{bm,t} = 1$ for $t = T_{bm} + 1$ and 0 otherwise, for $m = 1, 2$. In the following step the regression is estimated over feasible pairs of T_{b1} and T_{b2}, to find the minimal t-ratio for the hypothesis $\alpha = 1$, which means the strongest rejection of the null hypothesis of the unit root. Because the minimal value of the t-ratio does not follow the standard Dickey-Fuller distribution, it is compared with the critical values calculated by Perron and Vogelsang (1992). The following table shows the results of the unit root tests.

Table 3: Clemente, Montanes, and Reyes Unit Root Test for positive electricity reserve prices

enbw, T=1,123		optimal breakpoint=December 1. 2006	
$AR(2)$	DU_1	$rho-1$	$const$
coefficient	-131.510	-0.145	169.004
t-statistic	-17.401	-5.545	
p-value	0.0000	-3.560	

rwe, T=1,123		optimal breakpoint=December 1. 2006	
$AR(2)$	DU_1	$rho-1$	$const$
coefficient	-140.501	-0.139	174.999
t-statistic	-21.522	-5.893	
p-value	0.0000	-3.560	

eon, T=1,123		optimal breakpoint=December 1. 2006	
$AR(2)$	DU_1	$rho-1$	$const$
coefficient	-138.443	-0.139	160.687
t-statistic	-23.331	-5.591	
p-value	0.0000	-3.560	

vat, T=1,123		optimal breakpoint=December 1. 2006	
$AR(2)$	DU_1	$rho-1$	$const$
coefficient	-154.820	-0.139	188.510
t-statistic	-24.462	-5.806	
p-value	0.0000	-3.560	

The results of our tests are twofold: Firstly the tests confirm our hypothesis that there is a structural break on December 1. 2006, when the new regulatory regime was in charge for the first time. Furthermore, the four price series are non stationary. The results have two consequences: The first consequence is estimating the VAR models in first differences to avoid spurious regression problems and the second is estimating our models for the time periods before and after the structural break separately to investigate differences caused by the regulatory change. The following tables repeat the analysis for negative electricity reserve prices.

Table 4: Clemente, Montanes, and Reyes Unit Root Test for negative electricity reserve prices

enbw, T=1,123		optimal breakpoint=December 1. 2006	
$AR(2)$	DU_1	$rho-1$	$const$
coefficient	-74.905	-0.097	94.586
t-statistic	-39.938	-3.793	
p-value	0.0000	-3.560	

rwe, T=1,123		optimal breakpoint=December 1. 2006	
$AR(2)$	DU_1	$rho-1$	$const$
coefficient	-82.182	-0.094	100.370
t-statistic	-41.208	-3.571	
p-value	0.0000	-3.560	

eon, T=1,123		optimal breakpoint=December 1. 2006	
$AR(2)$	DU_1	$rho-1$	$const$
coefficient	-74.459	-0.097	92.758
t-statistic	-43.254	-3.403	
p-value	0.0000	-3.560	

vat, T=1,123		optimal breakpoint=December 1. 2006	
$AR(2)$	DU_1	$rho-1$	$const$
coefficient	-81.138	-0.101	100.197
t-statistic	-240.852	-3.985	
p-value	0.0000	-3.560	

VAR models are quite sensible with regard to the lag length of the relevant time series. We base our lag length selection on three familiar information criteria. The standard information criteria Akaike, Hannan-Quinn, and Schwarz-Bayes all suggest an optimal lag length of four for the VAR-model.

Table 4: Lag Length Selection

Lag	AIC	HQIC	SBIC
Positive Reserve Power Prices between April 1. 2006 and November 30. 2006			
4	36.578	36.891	37.363
Positive Reserve Power Prices between December 1. 2006 and May 30. 2009			
4	31.847	31.984	32.206
Negative Reserve Power Prices between April 1. 2006 and November 30. 2006			
4	32.934	33.247	33.719
Positive Reserve Power Prices between December 1. 2006 and May 30. 2009			
4	30.086	30.223	30.445

The estimation results of our VAR models can be found in tables X-X in the appendix. The following table provide information on the results of our Granger causality tests between the regional series of positive and negative reserve power prices as measures of interrelationship between the four regional markets.

Table 5: Granger Causality Tests for Positive Prices before Structural Break:

Lags	H_0	Granger-Causality
4	enbw → rwe	0.248 (0.619)
4	enbw → eon	0.273 (0.602)
4	enbw → vat	0.796 (0.372)
4	rwe → enbw	1.106 (0.293)
4	rwe → eon	0.785 (0.376)
4	rwe → vat	1.118 (0.290)
4	eon → enbw	0.662 (0.416)
4	eon → rwe	0.197 (0.657)
4	eon → vat	1.978 (0.160)
4	vat → enbw	0.356 (0.551)
4	vat → rwe	0.030 (0.863)
4	vat → eon	0.547 (0.459)

The results clearly show that there is no interrelationship measured by Granger causality between the four regions before the change in market design in December 2006. This result changes significantly after the change in regulatory structure as can be seen in the following table.

Table 6: Granger Causality Tests for Positive Prices after Structural Break:

Lags	H_0	Granger-Causality
4	enbw → rwe	45.268 (0.000)*
4	enbw → eon	56.443 (0.000)*
4	enbw → vat	32.428 (0.000)*
4	rwe → enbw	48.289 (0.000)*
4	rwe → eon	49.213 (0.000)*
4	rwe → vat	39.942 (0.000)*
4	eon → enbw	39.325 (0.000)*
4	eon → rwe	15.960 (0.000)*
4	eon → vat	42.690 (0.000)*
4	vat → enbw	33.547 (0.000)*
4	vat → rwe	22.228 (0.000)*
4	vat → eon	52.675 (0.000)*

After the structural break in December 2006, there is a statistical significant relationship between all price series of the four regions, which means that including prices from other regions in the information set of individual price series provides better forecasts of future prices than just using only past values of the own price series. As a result the change in regulatory environment clearly has effects on the interraltionship of regional electricity reserve markets in Germany. In the next step we extend our analysis on the series of negative electricity reserve prices in Germany.

Table 7: Granger Causality Tests for Negative Prices before Structural Break:

Lags	H_0	Granger-Causality
4	enbw → rwe	0.920 (0.337)
4	enbw → eon	0.319 (0.572)
4	enbw → vat	0.882 (0.348)
4	rwe → enbw	0.017 (0.898)
4	rwe → eon	0.429 (0.513)
4	rwe → vat	1.069 (0.301)
4	eon → enbw	0.015 (0.903)
4	eon → rwe	1.018 (0.313)
4	eon → vat	1.060 (0.303)
4	vat → enbw	0.054 (0.816)
4	vat → rwe	0.541 (0.462)
4	vat → eon	0.372 (0.542)

Our analysis of Granger causality between negative electricity reserve prices before regulatory change yields the same results as our analysis for the positive prices. Before the structural break, there is no interrelationship between regional markets measured by the concept of Granger causality. The following table shows the results for negative reserve prices after the structural break in December 2006.

Table 8: Granger Causality Tests for Negative Prices after Structural Break:

Lags	H_0	Granger-Causality
4	enbw → rwe	0.248 (0.618)
4	enbw → eon	4.117 (0.042)*
4	enbw → vat	1.318 (0.251)
4	rwe → enbw	0.514 (0.473)
4	rwe → eon	0.478 (0.490)
4	rwe → vat	1.837 (0.175)
4	eon → enbw	0.811 (0.368)
4	eon → rwe	0.573 (0.449)
4	eon → vat	4.497 (0.034)*
4	vat → enbw	2.423 (0.120)
4	vat → rwe	1.300 (0.254)
4	vat → eon	1.447 (0.229)

The set of Granger causality tests for negative electricity reserve prices after the structural change provides mixed results. In contrast to the results for positive reserve prices after December 1. 2006, we do not find interrelationships between al series. Our tests only detect Granger causality between enbw and rwe and vat and eon. In the case of negative electricity reserve prices changes in market interrelationships a less strong than for positive electricity reserve prices. VAR models estimated in first differences clearly measure short run relationships. Additionally, we tested for cointegration between the four regions because there may also be a long run interrelationship between regional electricity reserve markets, but we rejected al hypotheses of cointegration relationships between the four regions.

3.3 Determinants of regional Electricity Reserve Prices

3.3.1 Empirical Strategy

In the second part of our econometric analysis we take advantage of the panel structure of our data. The main advantage of such strategy is that we can take account of unobserved heterogeneity between the four regional markets in Germany by including fixed effects in our panel regressions. In the first steps of our analysis we detected a structural break in the price series for positive and negative electricity reserve prices. As a consequence, we estimate separate regressions for positive and negative prices for the time period before and after the change in market design in Germany. Taking into account the panel structure of our data, we can derive an adequate specification as

$$y_{it} = \alpha_{it} + \sum \beta_k x_{it,k} + \epsilon_{it}$$

where y_{it} represents the price variables and $.x_{it,k}$ are explanatory variables. ϵ_{it} is an error term and α and the β's are parameters to be estimated. Assuming that α_{it} is fixed over time, but differs with cross-section units, the equation can be estimated using fixed effects controlling for unobserved heterogeneity. Alternatively assuming that α_{it} can be composed into a common constant α and a unit specific random variable ν_i so that the equation $\alpha_{it} = \alpha + \nu_i$ holds, the equation can be estimated with the random effects model in this case. Controlling for unobserved heterogeneity we apply fixed (FE), because it seems to be a natural choice. Unobserved heterogeneity between regions is usually constant over time and as a result, fixed effecfts regressions are the better choice. To account for possible endogeneity problems we use instrumental variable techniques in our analysis especially with respect to the power prices of the European Energy Exchange included as explanatoty variables.

3.3.2 Econometric Results

In this section we present the results of our panel regressions to explain the determinants of electricity reserve prices in the four regions in Germany. To avoid spurious regressions problems, we run unit root tests for all variables. Only our variables for prices of coal and natural gas are stationary. All other variables are integrated of order one. The following tables show our results.

Table 9: Determinants of positive Electricity Reserve Prices

	before structural break		after structural break	
positive price	coeff	std. err.	coeff.	std. err.
EEX spot price	14.142***	5.712	0.905***	0.374
Oil price	2.952	4.973	-0.043	0.089
Price for natural gas	-1.077	8.477	-0.036	0.445
Price for coal	22.934**	11.444	0.029	0.112
Feed in of wind energy	0.008	0.007	0.0003	0.0002
time	-0.135	0.160	-0.0004	0.002
Obs.	1,248		3,412	
R^2	0.12		0.11	
Weak identification test	8.636 (bias about 10%)		19.260 (bias less 5%)	

*,**,*** statistically significant on the 10, 5, and 1% level. Standard errors are heteroskedasticity robust.

It is important to note that without using instrumental variable techniques, it is very likely that there may be an endogeneity problem with regard to the EEX spot price. We think that it is reasonable that there could be some feedback from electricity reserve markets to the EEX. To avoid these endogeneity problems, we instrument the EEX spot price using temperature data from different German cities. The idea is that there is no direct effect on prices at the EEX, but there are massive effects on prices on eletricity reserve markets. The weak identification test confirms our assumptions and shows rather small biases.

The following table shows similar regressions for negative electricity reserve prices.

Table 10: Determinants of negative Electricity Reserve Prices

	before structural break		after structural break	
negative price	coeff	std. err.	coeff.	std. err.
EEX spot price	-1.771	1.458	-0.927***	0.263
Oil price	-0.395	0.907	-0.010	0.055
Price for natural gas	0.965	1.640	0.306	0.225
Price for coal	-2.110	1.771	-0.084	0.072
Feed in of wind energy	-0.0003	0.001	0.0002	0.0002
time	0.029	0.027	-0.0008	0.002
Obs.	1,248		3,412	
R^2	0.09		0.32	
Weak identification test	2.491 (bias about 20%)		10.427 (bias less 15%)	

*,**,*** statistically significant on the 10, 5, and 1% level. Standard errors are heteroskedasticity robust.

In almost all cases there is a strong effect from spot prices on the EEX on electricity reserve market prices in the four regions in Germany. Only for negative prices before the structural break we cannot find a statistical significant effect. Furthermore, we can find a statistically significant effect from coal prices on positive electricity reserve prices before regulatory change. This effect is not measurable after the change in market design any more.

As a result, our panel regressions confirm the results of our time series analysis conducted before: The change in market design had significant effects on the working of the German market for electricity reserve.

4 Conclusion

Other papers analyzing the efffects of market reform on the working of the market for electricity reserve in Germany on the aggregate level found that the reform had no effects on reserve prices. Despite these findings, we find a structural break after the introduction of the new market design testing jointly for non stationarity and structural breaks. We extend the analysis and find that the reform also caused an increasing interrelationship between regional reserve markets and controling for unobserverd heterogeneity, we find a structural break in electricity reserve prices and different data generating processes before and after the structural break.

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