# The Fall in British Electricity Prices: Market Rules, Market Structure, or Both?*

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**Abstract**

In this paper we investigate the factors contributing to the fall in the Lerner Index (price-cost margin) in the British electricity market during the 90s. A first stage of our analysis models the number of breaks in the Lerner Index and their dating as unknowns. Our results suggest the existence of one structural break in the time series of the Lerner Index. The break point interval includes the go-live of the New Electricity Trading Arrangements (NETA), but also several other (but not all) regulatory interventions. In a second stage of our analysis, we construct a general regression model for the Lerner index as a function of the regulatory interventions within the estimated break point interval, the Herfindahl-Hirschman Index (HHI), and the demand-capacity ratio. The results show that both the HHI and the demand-capacity ratio are strongly significant for explaining the fall in the Lerner Index. NETA is also significant, even when the Lerner Index is corrected for the influence of the HHI and the demand-capacity ratio.

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# 1 Introduction

A major overhaul of the England and Wales electricity trading arrangements introduced in 1990 has recently taken place. The New Electricity Trading Arrangements (NETA) have replaced the Pool for a series of forward markets and a short-term 'balancing market'. Market participants are now expected to contract bilaterally for the exchange of energy in advance of actual production. The balancing market allows traders to fine tune their positions and the System Operator to change traders' plans if this is necessary to match overall supply and demand over the day. In contrast to the formerly used uniform-auction, the auction format used in the balancing market is of the discriminatory or 'pay-your bid' type (see Ofgem (1999)). The British regulatory authority, Ofgem, has recently reported that the month-ahead base-load prices fell by a 40% since the Government accepted the reforms in 1998 up to March 2002, i.e. one year after the 'go-live' of NETA (see Ofgem (2002)).

The issue of whether the new market rules embodied in NETA were responsible for the fall in prices has been subject to some controversy. There are mainly two views. The first one, advocated by Bower (2002) and Newbery (2003), argues that the change in the trading arrangements did not cause the decline in prices, which is fully explained by asset divestitures, the increase in imports, and a high degree of excess capacity. The second view, supported by the empirical analysis of Evans and Green (2002), argues that the announcement of NETA led firms to expect lower prices in the future, which favored the anticipated collapse of tacit collusion.[1] It is still an open question, both theoretically and empirically, whether it was market design or market structure what led to the improvement of market performance (see Fabra, von der Fehr and Harbord (2003)).

In this paper, we provide empirical support to a third view by which both the change in market rules and the decrease in concentration favored the drop of prices. We combine elements of the models developed by Bower (2002) and Evans and Green (2002), and enrich their methodology in order to quantify the explanatory power of variables related to the changes in market rules and market structure. We depart from Evans and Green (2002) by considering the number of breaks in the Lerner Index (price-cost margin) and their dating as unknowns. The regulatory interventions that take place within the estimated break point interval are then considered to be potentially relevant in explaining the drop in the Lerner Index. With this information, we then construct a general regression model that explains

[1] Sweeting (2001a) finds evidence of tacit collusion in the Pool during the late 1990s. Fabra (2003) shows, within a theoretical model that can be applicable to electricity auctions, that the sustainability of tacit collusion is easier under a uniform-price auction (as in the pre-NETA market design) as compared to a discriminatory auction (as in NETA).

the pattern of the Lerner index as a function of the relevant regulatory interventions, the Herfindahl-Hirschman Index (HHI), and the demand-capacity ratio. The robustness of the results is checked using different estimators and alternative definitions for the explanatory variables. We find that the break point interval estimated in our first set of regressions includes the 'go live' of NETA, but also several other (but not all) regulatory interventions. The HHI and the demand-capacity ratio are strongly significant in our general regression. NETA is also significant, even when the Lerner Index is corrected for the influence of the HHI and the demand-capacity ratio.

### 1.1 Review of previous works

Bower (2002) presents a regression model for British electricity wholesale prices. As explanatory variables, he considers a capacity concentration index for thermal plants and a set of dummy variables to take into account the various regulatory interventions. These include the publication of the Review of the Electricity Trading Arrangements (RETA), the Competition Commission's decision to remove the Market Abuse Licence Clause (MALC) from the generators' licences, the end of the gas moratorium, and the 'go live' of NETA. The most important result of Bower (2002) is that the response coefficient of NETA is not statistically significant, contradicting the view supported by Ofgem. He concludes that the drop in the wholesale price can be fully explained by the rapid decrease in market concentration shortly before NETA was introduced, combined with capacity expansions and new entry in the system.

The purpose of Evans and Green (2002) is to test empirically two alternative explanations for the drastic fall in the Lerner Index that took place in the British electricity market after 2000: one concerns the decrease in the concentration index from 2000 onwards, and the other relates to the change in the market rules embodied in the New Electricity Trading Arrangements. The first explanation is measured through the effect of the $HHI$ on the Lerner Index, whereas the importance of the second explanation is measured through the effects of two dummy variables aimed at capturing the impact of NETA. The first is a step dummy ($NETA_t$) that takes on the value one from the time at which NETA was introduced (April 2002), and zero otherwise. The second is a step dummy ($pre-NETA_t$) that takes the value one from the date at which the authors believe that NETA started to have an impact on pricing behavior (October 2000) until the introduction of NETA, and the value zero at all other periods.

These two dummies reflect two possible effects of NETA. The first one represents a static view, by which NETA only had an effect when the change of rules was actually implemented, whereas the second one reflects a dynamic view, by which the announcement of NETA made firms expect lower prices in the future and thereby caused the anticipated collapse of tacit collusion. When the static view is tested, the authors find that the drop in prices is fully explained by the decrease in concentration. When the dynamic view is tested, the concentration index is no longer significant, whereas the announcement effect becomes relevant. Given that the model associated with the dynamic view reports a better goodness of fit, the authors conclude that the anticipation of NETA favored the drop in the Lerner index.

# 2 The Empirical Analysis

## 2.1 Data Description

In order to identify the reasons underlying the fall in British electricity prices, we analyze the evolution of the Lerner Index over the period April 1996 to October 2002.[2] Our set of potential explanatory variables combines those analyzed by Evans and Green (2002) and Bower (2002). As in Evans and Green (2002), we have considered the demand to capacity ratio ($DemCap_t$), the $HHI_t$,[3] and an intervention variable capturing the 'go-live' of NETA ($NETA_t$).[4] As Bower (2002), we have also included some intervention variables that reflect the effect of the following regulatory measures: the agreement reached by Ofgem with National Power and PowerGen by which these generators would divest 4000 and 2000 MWs respectively through a lease agreement with Eastern Electricity ($EASTLEASE_t$); the end of the gas moratorium which prevented new gas-fired plants from entering ($GASMORAT_t$); the Review of the Electricity Trading Arrangements that first showed clear willingness to reform market rules ($RETA_t$); and the introduction of a Market Abuse Licence Clause into the generators' licences ($MALC_t$). These variables are plotted in Figures 1 and 2.

The left upper plot of Figure 1 depicts the evolution of the Lerner Index. It is characterized by a larger volatility after the first divestiture round and the end of the partial price-cap

[2] The Lerner Index is constructed using marginal cost estimates and monthly averages of the Pool Selling Price for the pre-NETA period, and the UKPX Reference Price Data for the post-NETA period (available at http://www.ukpx.com/).

[3] We have not followed Evans and Green (2002) in considering the squared HHI ($HHI^2$) as a potential explanatory variable capturing possible non-linearities in the relationship between the Lerner Index and the HHI. The reason for this is because the behavior of HHI and $HHI^2$ is almost identical. A simple regression of $HHI^2$ on HHI and a constant shows that squared $HHI^2$ is very well explained by HHI itself. As a further confirmation check for multicollinearity between these two variables we have done the following calculations. First, we have calculated the inverse of the matrix containing the cross-products of these two variables. Second, we have computed the square-root of the ratio of the highest to the smallest eigenvalues. The value of this ratio was above 29, which confirms that there is strong multicollinearity.

[4] A brief description of the construction of these variables can be found in Evans and Green (2002).

(mid-1996), whereas it records a lower mean and a less volatile behavior following the second divestiture round (mid-2000). The Lerner index reflects a spike in September 2000, which can be explained by an abnormal capacity payment. As in Evans and Green (2002), we model this abnormal capacity payment with a blip dummy variable taking a value of 1 on this specific month and 0s elsewhere. Moreover, the Lerner Index is characterized by a drop in the mean that seems to have taken place after the above-mentioned price-spike.

On the upper right hand side of Figure 1 we have plotted the $HHI$. Its gradual decline over the sample period can be explained by the divestiture of the major generators' assets. The first round of divestitures took place in July 1995, when National Power (NP) and PowerGen (PG) divested 6.2 GW (3.9 GW and 2.3 GW, respectively) of capacity to Eastern. This resulted in a steep drop in the $HHI$ in April 1996 (when the Index drops below 1,800) and in August 1998. A second round of divestitures took place between 1999 and early 2000, following a number of Ofgem investigations into the level of Pool prices and the desire of NP and PG to vertically integrate with the retail activity. This induced a gradual drop in the $HHI$ for coal and a corresponding reduction in prices.[5]

The left lower panel of Figure 1 reports the demand to capacity ratio, and the right lower panel decomposes it into demand and capacity. It is remarkable the increase in capacity from July 2000.

Figure 2 reports the timing of the regulatory interventions.[6] The upper panel records the dummies capturing the Eastlease divestiture ($EASTLEASE_t$), the gas moratorium ($GASMORAT_t$), the Review of the Electricity Arrangements ($RETA_t$) and the Market Abuse Licence Condition ($MALC_t$). A definition of the intervention dummies is reported in Table 1. The lower panel records the Lerner Index together with the blip dummy that records the abnormal behavior of the capacity payment that occurred in September 1999, the 'go live' of NETA and the Pre-NETA dummy, suggested in Evans and Green (2002), that tries to capture the possible effect that the anticipation of NETA could have had on pricing behavior.

A list of the summary statistics of the relevant variables under analysis is reported in Table 2. We also report the mean value of the Lerner Index under the different regulatory interventions (see Table 3).[7] One can easily see that there has been a structural change in

[5]Newbery (2003) has suggested that National Power and PowerGen could have had a strong incentive to keep prices high while they were attempting to sell power stations, but that this incentive would have fallen as soon as the sales were completed, in October 2000.

[6]Dummies are corrected for their means in order to facilitate plotting them together.

[7]The first row of Table 3 records the mean of the Lerner Index before any intervention considered in our analysis. The second row records the mean of the Lerner Index after the $EASTLEASE_t$ was introduced but

the mean of the Lerner in the last sample period under analysis (2000:5-2002:8), where the Lerner Index drops almost 40 %.

## 2.2 The empirical model and results

In order to more accurately assess the timing of the break and relate its dating to the regulatory interventions, we will first make inference of the date of the break. This analysis is carried out using the test for multiple breaks at unknown time (see among others Andrews (1993), Bai and Perron (1998), Bai and Perron (2001), Bai and Perron (2002a) and Bai and Perron (2002b)). These tests allow to estimate the times of the breaks without any *a priori* knowledge of their timing, and allow to construct confidence intervals for the break dates under very general conditions on the structure of the data and errors across segments. We first consider the case of a pure structural change model:

$$Lerner_t = z_t'\delta_j + u_t,\ t = T_{j-1} + 1, ..., T_j$$

for $j = 1, ...m + 1$, where $m$ are the potential number of breaks, $\delta_j$ $(j = 1, ...m + 1)$ are the corresponding coefficients and $z_t$ $(q \times 1)$ is the vector of covariates (in our case, just ones as we are modelling the changes in the mean). The break points $(T_1, ..., T_m)$ are treated as unknowns and the convention $T_0 = 0$ and $T_{m+1} = T$ is used.

The purpose of the analysis is to estimate the unknown regression coefficients together with the break points. Table 4 reports the results of this analysis. The sequential test (Sequential), the Bayesian Information Criterion (BIC) and the Liu, Wu and Zidek (1997) criterion suggest the existence of a single break (see Liu et al. (1997), Yao (1988) and Bai and Perron (2002b)). The estimates of the two means for the Lerner Index are respectively $\widehat{\delta}_1 = 0.52$ and $\widehat{\delta}_2 = 0.27$, which imply a drop of 48 %. Our estimation confirms that the mean of the Lerner Index is characterized by a single break that took place around November 2000 ($\widehat{T}_1$= 2000:11).

Evans and Green (2002) modelled the pre-announcement effects of NETA with a step dummy that took the value of 1 from October 2000 to March 2001 and zero elsewhere. Though our estimate of the break point is very close to theirs, the 95 % confidence interval for the dates of the break (reported in parentheses just below the date estimate, $\widehat{T}_1$) is wide

just before the $GASMORAT_t$ was introduced (1996:7-1997:12). The third row of Table 3 records the same statistic for the period when the $GASMORAT_t$ was introduced and RETA took place (this corresponds to the period 1997:12-1998:7). The fourth row of Table 3 records the mean of the Lerner Index just after $MALC_t$ was introduced until it finished (1999:10-2000:12, in this period, the $EASLEASE_t$, $GASMORAT_t$ and $MALC_t$ where all in place). The last row of Table 3 records the Lerner Index after NETA 'go-live'. The third column of Table 3 records the standard deviation for the statistic reported in the second column.

enough so as to include the start of NETA. The interval estimate for the break point also includes other regulatory interventions such as the end of the Gas Moratorium (October 2000) or the Competition Commission decision to remove the Market Abuse License Clause (December 2000).

Moreover, these same dates coincide with a considerable increase in the available capacity and a small drop in the $HHI$ (see Figure 1). In order to investigate whether these two variables could fully account for the drop in the Lerner Index, a similar analysis is performed for the case in which the Lerner Index is first corrected for the influence of the $HHI$, the September 2000 blip dummy, and the demand-capacity ratio. Our results still show a structural break at the date reported in Table 4, with similar interval estimates.[8]

The main objective of next stage in our empirical analysis is to assess which of the several regulatory interventions within the interval estimate for the break point is responsible for the drop in the Lerner Index, given the behavior of the other variables modelled ($HHI_t$ and $DemCap_t$). The potential autocorrelation in the residuals is modelled with an autocorrelated error term.[9] The model for the Lerner Index could be represented by the following equation:

$$\begin{aligned} Lerner_t \quad = \quad & Const + \beta_1 HHI_t + \beta_2 DemCap_t + \beta_3 NETA_t + \beta_4 GASMORAT_t + \\ & \beta_5 EASTLEASE_t + \beta_6 MALC_t + \beta_7 DumBlipSep00_t + \\ & \beta_8 DumStep96June_t + u_t \end{aligned} \quad (1)$$

with:

$$u_t = \rho u_{t-1} + \varepsilon_t$$

A first estimation of Equation (1) showed that $EASTLEASE_t$ and $MALC_t$ were statistically insignificant - the impact of the divestiture to Eastern Electricity may already be captured by the HHI. Once these variables were deleted from our original model, this was re-estimated. The results are reported in Table 5. All the coefficients report the expected sign and are significant at the 5% significance level, with NETA marginally significant at the 10%.[10]

[8] These are not shown here and are available from the authors upon request.

[9] The source of this autocorrelation is mostly induced by the averaging needed in order to work with monthly observations, together with the specific seasonal component that could be carried in the marginal cost calculations as the marginal cost is calculated as the intersection of the industry aggregate marginal cost curve and demand.

[10] If we avoid modelling the residual autocorrelation but instead use Jacknifed Autocorrelation and Heteroskedastic Consistent Standard Errors in order to do proper inference, NETA comes out as strongly significant (see the results in the Appendix).

## 3 Conclusions

The results presented in this paper offer additional evidence on the reasons underlying the fall in British electricity prices from 1998 onwards. Our econometric analysis confirms a third view that sustains that both market rules and market structure were jointly responsible for the reduction in mark-ups. The most novel aspect of our methodology is the fact that we treat the break points and their dating as unknowns. The estimated time interval for the break suggests a set of regulatory interventions that could jointly explain the break in the Lerner Index. Importantly enough, we find that the go-live of NETA is included in the estimated break point interval. This information is used in the regression analysis, which further confirms that the $HHI$ and the implementation of NETA are strongly significant in explaining the fall in the Lerner Index in the British electricity market. We see this analysis as a contribution to the debate about market rules versus market structure, an issue which is critical in the evolving process of reform in the electricity industry in the UK and elsewhere.

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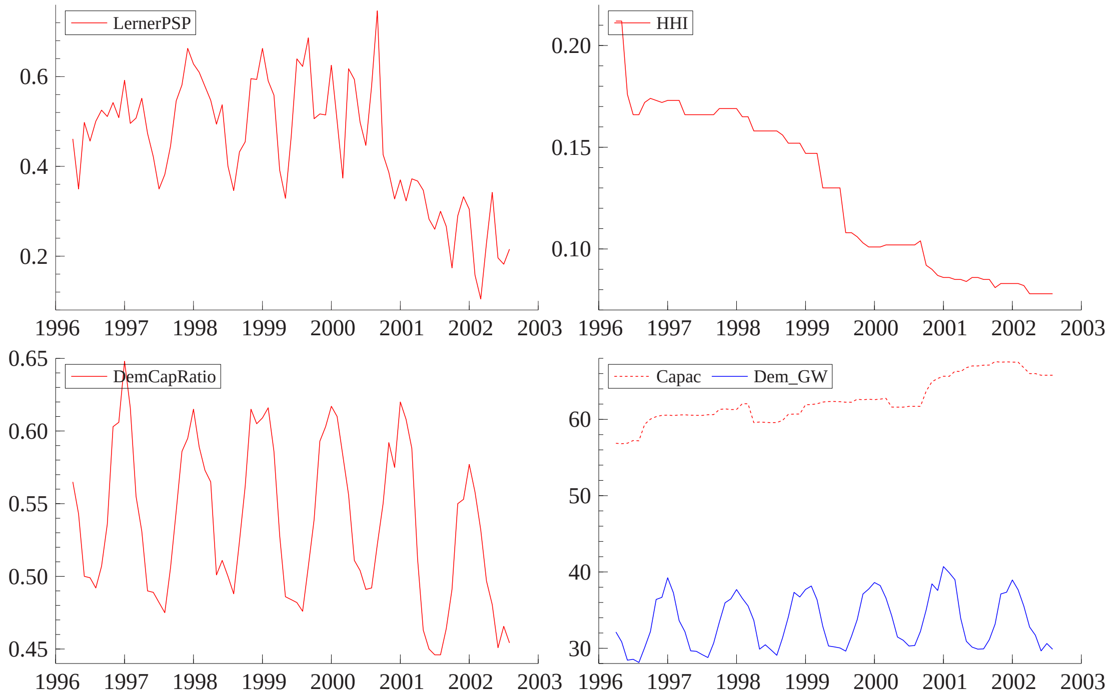


Figure 1: The Lerner Index, the HHI, and the Capacity Demand Ratio

Table 1: Description of the intervention dummies

| Variable | Regulatory Intervention | Definition |
|---|---|---|
| $EASTLEASE_t$ | The First Coal Divestiture | $I_{(July96>t<Dec00)}$ |
| $GASMORAT_t$ | The Gas Moratorium | $I_{(Dec97>t<Oct00)}$ |
| $RETA_t$ | Review of Electricity Trading Arrangements | $I_{(Nov97>t<July98)}$ |
| $MALC_t$ | Market Abuse Licence Clause | $I_{(Oct99>t<Dec00)}$ |
| $NETA_t$ | New Electricity Trading Arrangements | $I_{(Aprilt01>t<March02)}$ |

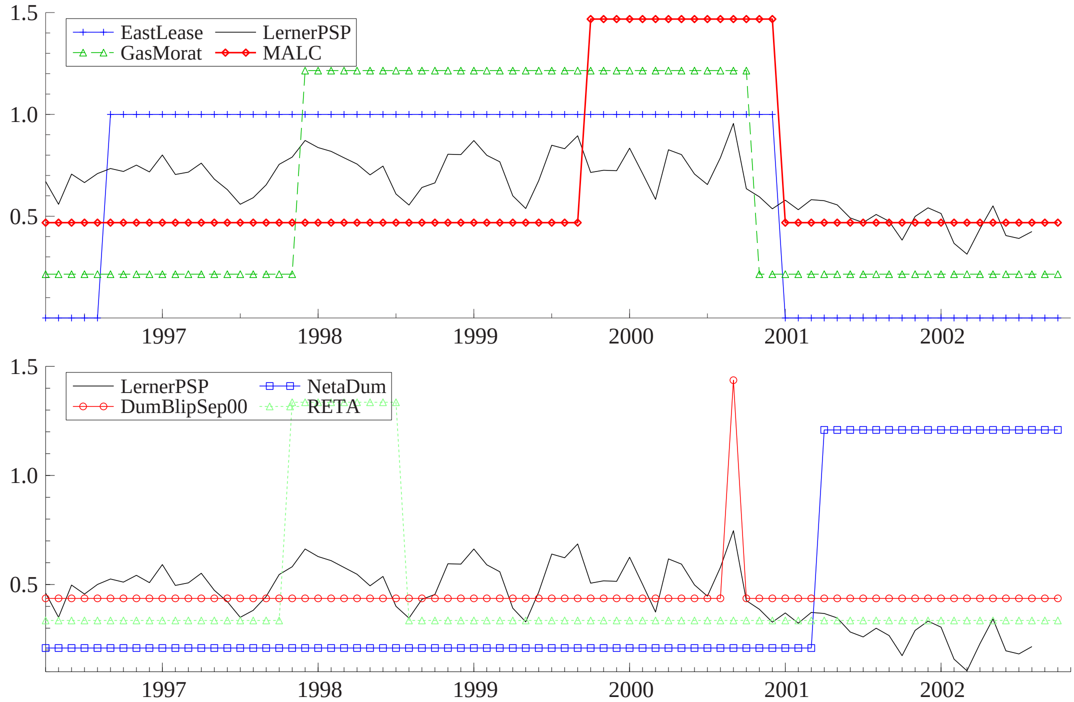


Figure 2: Intervention Dummies and the Lerner Index

Table 2: Descriptive statistics

| Variable | Mean | StdDev | Min | Max |
|---|---|---|---|---|
| $MC_t$ | 12.16 | 1.030 | 10.37 | 14.57 |
| $PSP_t$ | 23.55 | 6.393 | 12.97 | 45.05 |
| $Lerner_t$ | 0.368 | 0.133 | 0.058 | 0.642 |
| $HHI_t$ | 0.128 | 0.038 | 0.078 | 0.212 |
| $Demand_t$ | 33.52 | 3.486 | 28.14 | 40.71 |
| $Capacity_t$ | 62.49 | 2.898 | 56.81 | 67.57 |
| $DemCap_t$ | 0.536 | 0.053 | 0.446 | 0.648 |

Table 3: Descriptive statistics for the Lerner Index for different regulatory periods

| Lerner | Mean | Variance | Min | Max |
|---|---|---|---|---|
| Full Sample (1996:4-2002:8) | 0.368 | 0.133 | 0.058 | 0.642 |
| Partial Sample (1996:7-1997:12) | 0.516 | 0.096 | 0.327 | 0.746 |
| Partial Sample (1997:12-1998:7) | 0.557 | 0.077 | 0.400 | 0.663 |
| Partial Sample (1999:10-2000:12) | 0.510 | 0.106 | 0.327 | 0.746 |
| Partial Sample (2000:5-2002:8) | 0.265 | 0.076 | 0.104 | 0.367 |

Table 4: Bai and Perron Tests for Structural Change with Unknown Dates. The sample period is: 1996 (5) to 2002 (8)

| Number of Breaks Selected | | | |
|---|---|---|---|
| Sequential | 1 | | |
| LWZ | 1 | | |
| BIC | 1 | | |
| Estimates with one break | | | |
| | $\widehat{\delta}_1$ | $\widehat{\delta}_2$ | $\widehat{T}_1$ |
| Estimates | 0.52 | 0.27 | 2000:11 |
| Corrected Standard Errors | (0.021) | (0.031) | (2000:5−2001:4) |

Table 5: Modelling the Lerner Index by Autoregressive Least Square (ALS). The sample period is: 1996 (5) to 2002 (8)

| Variable | Coefficient | Std.Error | t-value | t-prob |
|---|---|---|---|---|
| $Constant$ | -0.0056 | 0.17 | -0.03 | 0.97 |
| $HHI_t$ | 1.1103 | 0.55 | 2.01 | 0.04 |
| $DemCap_t$ | 0.5313 | 0.26 | 2.03 | 0.04 |
| $NetaDum_t$ | -0.0819 | 0.05 | -1.50 | 0.13 |
| $GasMorat_t$ | 0.0964 | 0.03 | 2.82 | 0.00 |
| $DumBlipSep00_t$ | 0.2423 | 0.06 | 3.53 | 0.00 |
| $\widehat{\rho}$ | 0.4619 | 0.10 | 4.27 | 0.00 |

## Appendix: Robustness

In order to check for the robustness of the results and confirm the significance of NETA, we re-estimate our previous model (Equation 1) without modelling the potential autocorrelation in the residuals but calculating the appropriate covariance matrix in order to obtain heteroskedastic and autocorrelated consistent standard errors. The estimated model is:

$$\begin{aligned} Lerner_t &= Const + \beta_1 HHI_t + \beta_2 DemCap_t + \beta_3 NETA_t + \beta_4 GASMORAT_t \\ &\quad + \beta_5 DumBlipSep00_t + u_t \end{aligned}$$

Results for this model are reported in Table 6.

Table 6: Modelling the Lerner Index by OLS. The sample period is: 1996 (5) to 2002 (8)

| Variable | Coefficient | Std.Error | t-value | t-prob | JHCSE |
|---|---|---|---|---|---|
| $Constant$ | 0.0721 | 0.128 | 0.55 | 0.57 | 0.12 |
| $HHI_t$ | 0.9760 | 0.360 | 2.70 | 0.00 | 0.38 |
| $DemCap_t$ | 0.4302 | 0.199 | 2.16 | 0.03 | 0.20 |
| $NetaDum_t$ | -0.1087 | 0.039 | -2.75 | 0.00 | 0.03 |
| $GasMorat_t$ | 0.0936 | 0.023 | 3.95 | 0.00 | 0.02 |
| $DumBlipSep00_t$ | 0.2547 | 0.085 | 2.98 | 0.00 | 0.35 |

In order to further confirm the robustness of our results and the significance of NETA, we have performed two further experiments. First, we have taken into account the fact that the real effect of the HHI would appear at a level below 1,800 (see United States Department of Justice (1997)). We have thus constructed a new dummy that takes the value 1 for all the periods when the HHI index is below 1,800, and substituted this variable for the $HHI$ variable in our Equation (1). The results on the sign, magnitude and significance of the results hardly change. Second, we have considered the possible non-linearity of the $HHI$. We have already discussed that including $HHI$ and $HHI^2$ jointly in the equation for the Lerner Index would induce multicollinearity between these two regressors. It is worth pointing out that using the approach developed by Fabra et al. (2003), it is easy to see that expected prices are quadratic in the $HHI$ under the uniform auction, and linear in $HHI$ in the discriminatory case. We thus construct a new variable, made up of $HHI^2$ until NETA is introduced, and $HHI$ from then onwards. This would first solve the multicollinearity issue, and second, it would take account of non-linear effects, if there were any. The response coefficients from this formulation hardly changed compared with those reported in Table 5.[11]

[11] These results are available from the authors upon request.