Cambridge Working Papers in Economics CWPE 0326

UNIVERSITY OF CAMBRIDGE
Department of Applied Economics

Why Did British Electricity Prices Fall after 1998?

Joanne Evans and Richard Green

The Cambridge-MIT Institute

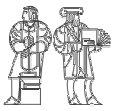
Massachusetts Institute of Technology
Center for Energy and
Environmental Policy Research

CMI Working Paper 26

Cambridge Working Papers in Economics

UNIVERSITY OF
CAMBRIDGE
Department of
Applied Economics

Not to be quoted without permission



The
Cambridge-MIT
Institute

Massachusetts Institute of Technology
Center for Energy and
Environmental Policy Research

CMI Working Paper

Why did British electricity prices fall after 1998?

Joanne Evans and Richard Green*
University of Hull

Centre for Economic Policy
University of Hull Business School
Hull HU6 7RX

Tel: +44 1482 465720
Fax: +44 1482 466216
Email: j.e.evans@hull.ac.uk, r.j.green@hull.ac.uk

January 2003

Abstract

In an attempt to reduce high electricity prices in England and Wales the government has reduced concentration among generators and introduced New Electricity Trading Arrangements (NETA). Econometric analysis on monthly data from April 1996 to September 2002 implies support for two conflicting hypotheses. On a static view, increases in competition and the capacity margin were chiefly responsible for the fall in prices. If generators had been tacitly colluding before NETA, however, the impending change in market rules might have changed their behaviour a few months before the abolition of the Pool. That view implies that NETA reduced prices.

JEL: L94
Keywords: Electricity, market power, concentration, market rules

* We gratefully acknowledge support for Joanne Evans via an arms-length grant from BNFL Magnox Generation Ltd. We would like to thank John Bower, Alex Henney, William Hogan, Paul Joskow, Stephen Littlechild, Luciano Losekann, David Newbery, Michael Ryan and Stephen Trotter for helpful comments. We would also like to thank Paul Barnes, Andrew Sweeting, and Stephen Topping for help with our cost estimates, and Mark Brackley, Adam Higginson, and David Hunt for help with data sources. The responsibility is ours alone.

1. INTRODUCTION

It is a truth universally acknowledged, that an electricity market with high prices is in want of a remedy. The causes of high prices include insufficient generation capacity, market power stemming from excess concentration among generators, and inappropriate market rules. The natural remedies are, in turn, to encourage the addition of more generation capacity, to negotiate or impose a more competitive market structure, and to change the market rules. In England and Wales, electricity prices in the second half of the 1990s were persistently above the costs of new entrants. Towards the end of the decade, more capacity was added, and two of the largest generators divested a significant proportion of their plant. On March 27, 2001, a new set of trading rules came into force. Wholesale prices are now 40% lower than when the industry's regulator first suggested reforming the trading system.

England and Wales have thus experienced all three of the classical remedies for high electricity prices. This paper is an attempt to assess which of those remedies had the greatest impact on the level of electricity prices. In particular, we hope to shed light on the extent to which the adoption of the New Electricity Trading Arrangements (NETA) directly caused the drop in wholesale prices which occurred at about the same time.

The next section of the paper considers the history of the electricity industry in England and Wales and the decision to introduce NETA. Section 3 considers some of the prior academic work on market power in the electricity industry. Section 4 introduces the regressions that we have run to measure the impact of NETA, and of other changes during this period. Sections 5 and 6 present our results, and section 7 concludes.

2. THE ELECTRICITY INDUSTRY IN ENGLAND AND WALES

The electricity industry in England and Wales was restructured on March 31, 1990. The state-owned Central Electricity Generating Board was divided into the National Grid Company, responsible for transmission, and three generating companies. Two of these, National Power and PowerGen, with 50% and 30% of the industry's capacity respectively, were privatised in February 1991. Nuclear Electric owned almost all of the remainder, but was kept in state ownership, as its nuclear reactors were believed to be too expensive to privatise. A failed attempt to privatise the nuclear stations had been the main motive for creating a company as large as National Power, in the hope that it would be large enough to absorb the risks of nuclear power. The stations had to be withdrawn from the sale in November 1989, and there was not enough time for significant changes to the restructuring plan.

The centre-piece of the restructuring was a spot market known as the Pool. Each day, this accepted bids from all the generators, and used a version of the CEGB's cost-minimising software to draw up an operating schedule and to calculate the System Marginal Price (SMP) for each half-hour. This was broadly equal to the average bid cost of the marginal station in each half-hour. Generators received the SMP for every unit of output that they were scheduled to generate, and received a capacity payment for every MW of available capacity. This payment was equal to the Loss of Load Probability multiplied by the net Value of Lost Load.

The cost of deviations from the schedule, due to forecasting errors, plant failures, and transmission constraints, of making capacity payments to generators who had not been scheduled to generate, and of buying ancillary services such as reserve, were recovered in a charge called Uplift. Uplift was added to the Pool Purchase Price to give the Pool Selling Price (PSP), payable by all suppliers for every unit that they bought through the Pool.

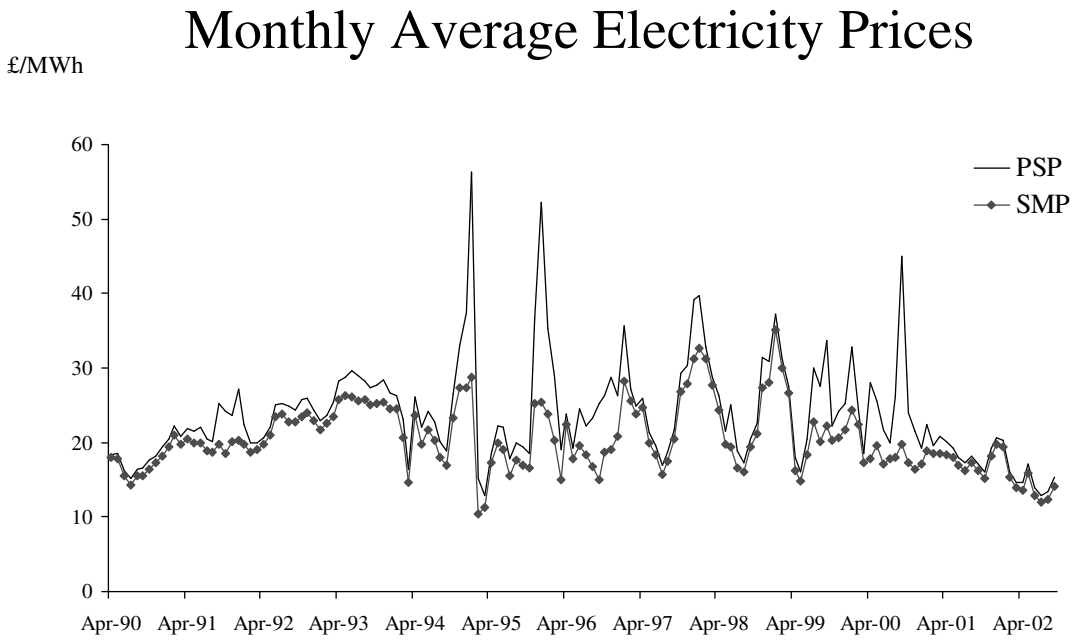


Figure 1

Legally, almost all electricity had to be traded through the Pool, although in practice, most of it was hedged with contracts for differences, which allowed generators to "lock in" their revenues in advance. In 1990, most of the generators' sales were hedged with three-year "coal-related" contracts at relatively high prices, above the expected level of Pool prices. This was because Pool prices were expected to be related to the marginal cost of generating using imported coal, while the generators were contracted to buy large quantities of British coal at higher prices. The coal-related contracts passed the difference in cost on to the Regional Electricity Companies (RECs), which were in turn allowed to pass the cost on to their (captive) smaller customers.

In its first year, Pool prices (shown in figure 1) were lower than expected, in part because the generators were competing to burn as much coal as possible. Over the following years, however, average Pool prices rose significantly, while there were suggestions that the generators were "gaming" particular aspects of the rules to increase their revenues. The industry's regulator issued a series of reports which criticised some aspects of this behaviour, but conceded that while prices were below the major generators' avoidable costs, it was reasonable for them to increase. By July 1993, however, the regulator concluded that prices had now risen above the level of the generators' avoidable costs, and announced that he would decide whether he should refer them to the Monopolies and Mergers Commission.

In February 1994, he announced that he had decided not to refer the companies to the MMC, at least for a two-year period. This was because they had given him undertakings to sell or otherwise dispose of 6 GW of plant, and to keep prices below a specified level during 1994/5 and 1995/6, while the sales were being arranged. National Power eventually leased 4 GW of plant to Eastern Electricity, while PowerGen leased 2 GW. Eastern had agreed to pay an "earn-out" of £6/MWh for each unit that the leased stations generated, which raised its bids, while the company also proved adept at exploiting loopholes in the Pool rules to increase its revenues. The flow of reports from the regulator continued.

In the autumn of 1997, it became clear that the demand for coal was due to fall significantly when the second round of "coal-related" electricity contracts expired in April 1998. The expiry of the first round had provoked a political crisis for the Conservative

government of the day, while the new Labour government had strong emotional ties to the coal industry. Coal had been displaced by the new CCGTs, and the high level of wholesale prices continued to encourage entry, even though the avoidable costs of the displaced coal stations were arguably lower than those of the CCGTs replacing them.[1] A temporary moratorium on new gas-fired stations gave the coal industry some hope, while the regulator was asked to conduct a review of electricity trading arrangements, to examine whether these had been responsible for some of the problems in the industry.

The review concluded that the Pool had a large number of faults, and that it should be replaced by new electricity trading arrangements (NETA) (Offer, 1998). The Pool's single-price rule was argued to make it easier for generators to exploit their market power, since they could submit low bids for part of their capacity, guaranteeing that it would run, while a small number of high bids would set the price for the whole market. This price umbrella had also encouraged the entry that was driving down the demand for coal. The Pool's complexity had created many opportunities for gaming, while the market's compulsory nature went against the principle of freedom of choice. These arguments were not uncontroversial (see e.g. Newbery, 1998b, Green, 1999a), but were accepted by the government.

The Department of Trade and Industry and the regulator (now called Ofgem) together created the New Electricity Trading Arrangements, based upon bilateral trading and a balancing mechanism to keep the system stable in the last few hours before real time. The balancing mechanism was the only centrally-designed market, and more than 95% of electricity is traded on over-the-counter markets or power exchanges. Traders have to notify NGC of their intended physical position at "Gate Closure", originally set 3½ hours before real time, but brought forward to one hour before real time in July 2002. Generators and suppliers submit bids and offers to adjust those positions, and NGC keeps the market in balance by accepting some of these. The average cost of the accepted bids (to buy power from NGC) is the System Sell Price, while the average cost of the accepted offers (to sell additional power to NGC) is the System Buy Price. On average, the System Buy Price is much higher than the System Sell Price. After the event, the Balancing and Settlement Company, Elexon, compares every firm's contractual position with its physical position. Companies which were short of power have to buy some at the System Buy Price, while those with a surplus are paid the System Sell Price. Companies with supply and generation have separate imbalances for each side of their business. Because the System Buy Price is generally much higher than the System Sell Price, imbalances are costly, and this was intended to give participants an incentive to balance their positions before Gate Closure. In practice, companies seem to have been anxious to minimise their exposure to the System Buy Price, which is much the more volatile, and have generally had a surplus of power at Gate Closure, rather than a balanced position.

The government and the regulator hoped that changing from the Pool to NETA, which finally took effect on March 27, 2001, would in itself reduce the generators' market power. There were other developments in the run-up to the new market's introduction, however. In June 1998, the regulator had recommended that the major generators should be required to divest more of their plant, and the government had accepted this recommendation in its response to the NETA proposals. PowerGen offered to divest 4 GW of plant if it was allowed to acquire East Midlands Electricity, and National Power was required to divest 4 GW in return for acquiring Midlands Electricity's supply business. Both companies followed these sales with others that were completely voluntary, however. They may have expected prices to fall in future, and preferred to sell plant at prices that seem not to have reflected these expectations.

[1] Until the decision to build a new station has been made, practically all of its costs are avoidable, unlike the capital costs of an existing coal station.

National Power divided itself into two companies, Innogy (with most of the UK assets) and International Power (with one UK power station and the company's overseas assets). Innogy subsequently bought two more REC supply businesses (Yorkshire and Northern). Eastern Electricity, which had been renamed TXU, bought a second supply business (Norweb), as did London Electricity, owned by Electricite de France (SWEB). British Energy, which had been privatised with the more modern nuclear plants in 1996, started to move towards vertical integration by acquiring Swalec's supply business, but sold the business within two years, realising that it was unlikely to acquire the five million customers generally believed to confer minimum efficient scale. The company bought a 2 GW coal-fired station instead, to help in balancing its inflexible nuclear stations. Swalec's supply business was acquired by Scottish and Southern Energy, which combined Southern Electric and Hydro-Electric.[2]

This means that by the time NETA took effect, the generation side of the industry was less concentrated than when it was first suggested, and there was also much more vertical integration. Academic work on electricity markets suggests that the combination of reduced concentration and increased integration was likely to reduce prices.

3. MARKET POWER IN ELECTRICITY

The first studies of market power in the British electricity markets were written soon after those markets were established. Green and Newbery (1992) argued that an electricity pool could be modelled as if generators competed by submitting supply functions, and showed that the equilibrium of this model in a concentrated industry would imply prices well above marginal costs. Von der Fehr and Harbord (1993) produced similar conclusions using an auction approach. Their results draw out an explicit link between the amount of spare capacity in the industry and the level of prices: prices will be much higher if neither firm is capable of meeting demand on its own.

Wolfram (1998, 1999) studied bids and prices in the England and Wales market. She found that the mark-ups between price and marginal cost were higher when demand was above the median level, and that generators tended to submit higher bids, relative to marginal costs, the greater the level of capacity that was infra-marginal to the bidding plant. Sweeting (2001) finds that mark-ups in a given quarter are generally higher when there is little spare capacity. He finds that mark-ups vary over time, however, and relates this to changes in concentration and to collusion. In particular, he suggests that generators changed their behaviour from not exploiting their (considerable) market power in the mid-1990s to exploiting the (much lower) degree of market power that remained to them, and possibly even colluding[3] by the end of his sample period in 2000.

An alternative explanation for changes in generators' behaviour over time, to which both Sweeting and Wolfram allude, is a change in their contractual position. Powell (1993), Newbery (1998a) and Green (1999b) all show that if generators have covered most of their output with contracts for differences, they will have little incentive to raise the price in the spot market. Green showed that the major generators had covered most of their output with contracts during the first five years of the Pool, even though the falling volumes of coal-

[2] After the end of our period, London Electricity took over Seeboard, while PowerGen acquired the Eastern and Norweb supply businesses from their near-bankrupt owner, TXU Europe.

[3] By colluding, Sweeting implies that the generators were producing less output than would have been privately profitable in a one-shot game, given their costs and the supply functions submitted by the other market participants.

related contracts meant that they could have allowed their contract cover to decline significantly.

The key result for our purposes is that a generator that has fully covered its expected output with contracts for differences will bid that level of output at marginal cost. Its bids for output above that level will be above marginal cost, while its bids for output below the contracted level would optimally be below marginal cost. Wolak (2000) uses very detailed data from the Australian electricity market to illustrate how these relationships held in practice. While we must be careful in moving between the absolute level of output and the level relative to the generator's contractual position (since this position will change from season to season), we might still expect this effect to give a positive relationship between demand and mark-ups.

There are a number of theoretical studies of the impact of different market rules. Bower and Bunn (2000) used a simulation model to predict that moving from a daily auction with a uniform price to hourly auctions with discriminatory pricing (i.e., from a simplification of the Pool system to NETA) would lead to higher prices. Fabra (2002), however, shows in a theoretical model that a discriminatory auction is less vulnerable to the exercise of market power than a uniform-price auction is. The uniform-price auction allows generators to receive a high price while still submitting low bids, and therefore minimising the pay-off from deviating to a more competitive strategy. Fabra et al (2002) compare several auction formats and find that their welfare ranking is ambiguous – uniform price auctions are (weakly) more efficient, but a discriminatory auction is (weakly) better for consumer surplus. In other words, the switch to NETA might be expected to reduce prices.

Bower (2002) is the only other empirical study of the impact of NETA that we are aware of. He estimates equations for monthly average prices from April 1990 to March 2002, using fuel prices, concentration, the level of demand, and regulatory interventions as his main explanatory variables. Our work is in many ways a response to his, sharing some of his approach. We discuss his results in more detail below, once we have explained our own choice of explanatory variables.

4. MODELS AND DATA

The discussion of the previous section suggests that the level of concentration and the margin between available demand and capacity are key determinants of mark-ups in the electricity industry, along with the (generally unobservable) level of contracting. It is straightforward to obtain data for Pool prices, and we concentrate on monthly averages of the System Marginal Price and the Pool Selling Price (including Transmission Uplift from its introduction in April 1997, since this represents costs previously included in Uplift). Since NETA, the closest equivalent to Pool prices is the UKPX Reference Price Data,[4] which gives an average of the prices in the UKPX's market, operating in the last day or so before real time. When looking at SMP, we use the UKPX price on its own as our post-NETA price. When looking at PSP, we need to add the costs of transmission and system balancing. NGC publishes its Balancing Services Use of System Charge, while Elexon publishes figures for the Residual Cash-flow Reallocation, which recycles any net profit from settling imbalances to market participants.[5] A true picture of the costs that suppliers face under NETA would also include the costs of

[4] UKPX Reference Price Data is used under licence agreement with OM London. The UKPX is the UK Power Exchange, the leading short-term market for electricity in England and Wales.

[5] NGC has normally needed to buy surplus power from participants who have avoided the System Buy Price by going long, and so this Reallocation has sometimes actually required market participants to give more money to NGC.

imbalances. We have daily volumes of positive and negative consumption imbalances. We therefore assume that suppliers purchased their actual demand, plus their positive imbalance, less their negative imbalance, at the daily average of the UKPX Reference Price Data, sold their positive imbalance at the daily average of the System Sell Price, and bought their negative imbalance at the daily average of the System Buy Price. We divide the total by the actual level of demand to get the average cost per MWh. This might underestimate the cost of imbalances, if the System prices are positively correlated with the level of imbalances in particular half-hours, but half-hourly imbalance data were not available to us. Finally, we reduce the post-NETA prices to reflect the fact that suppliers now only pay 55% of transmission losses. Under the Pool, their metered demands were scaled up by an average of 1.5% so that metered demand (on the transmission system) equalled metered generation, and the Pool Selling Price was applied to this scaled demand. Under NETA, demand is scaled by little more than half this amount, reducing the effective cost to suppliers.

We use a simplified merit order model to estimate the marginal cost of power. We have data on the monthly registered capacity of power stations in England and Wales, and on the monthly cost of fuel. We use the price paid by Major Power Producers for gas and for oil, as reported in Energy Trends, and Eurostat figures on the monthly cost of imports into the UK for coal.[6] We believe that the import cost is a better reflection of the marginal cost of coal than the price paid by the major power producers, which reflected the high-price, but fixed volume, 1993-98 coal contracts. To reduce volatility in the Eurostat data, we take a three-month moving average. We assume thermal efficiencies of between 31% and 37% for coal stations, 43% and 53% for CCGTs, and 36% for oil stations. To account for the "earn-out", we added £6/MWh to the marginal cost of the stations that Eastern leased from the major generators during the relevant periods. In the case of the 2 GW of ex-PowerGen stations, this was between July 1996 and March 2000 (inclusive), while in the case of the 4 GW of capacity leased from National Power, the earn-out lasted from June 1996 until December 2000.

We do not attempt to adjust the capacity of fossil-fuelled stations for actual availability, since this was potentially a strategic variable for the generators, but scale back the registered capacity of fossil stations by between 10% (winter) and 20% (summer) to account for outages. Nuclear capacity is similarly sculpted between months, and then scaled to track the actual annual figures for nuclear output. We estimate marginal cost for the monthly peak demand, the 5th percentile, 10th percentile, and so on, and take the unweighted average of these costs.[7] This ensures that we capture the convexity of the marginal cost curve.

Our estimated marginal cost followed the expected seasonal pattern (i.e., higher in winter) in most years, and was highest towards the end of our sample, when fuel prices rose. This gave us a problem in estimation, since the correlation with low electricity prices at the end of the sample gave us negative coefficients when we regressed the level of electricity prices on a model including the level of marginal costs. We therefore imposed the appropriate sign on marginal costs by using the Lerner index (the unweighted average price over the month minus the average marginal cost, divided by price) as our dependent variable.

We estimate parsimonious regressions with two main explanatory variables. Our data on monthly registered capacities allowed us to calculate a Herfindahl index for overall capacity ownership, summing the squared shares of capacity. As before, we do not attempt to adjust this for actual plant availability. While it is easy to show that the relationship between the Herfindahl index and the Lerner index in an industry of symmetric Cournot (quantity-

[6] We have recently extended our data-set, and used Energy Trends figures (which had converged with the Eurostat data) for the last six months of coal prices as an interim measure.

[7] We did not have the actual monthly load-duration curves for July 1999 to March 2001, but fitted the average of the curves for the corresponding months earlier in our sample to the average demand level for that month.

setting) firms is linear, most supply functions are non-linear. Furthermore, Green and Newbery's work (1992) suggests that there might be a non-linear relationship between the number of firms in the industry and the position of the industry's supply function. We therefore use both the Herfindahl index and its square as explanatory variables.

Our second main explanatory variable was the ratio of average demand during the month to registered capacity. The first variable is intended to pick up the effect of competition on prices, while the second is intended to capture the effect of the level of spare capacity available.[8]

We have 78 monthly observations from April 1996 until September 2002. Prices between April 1994 and March 1996 were distorted by the generators' undertaking on Pool prices, while price behaviour in the very early years of the Pool was dominated by the effects of the coal contracts. The last five years of the Pool gives us a reasonable length of data, with a varying amount of regulatory pressure. We currently have eighteen months of data after the introduction of NETA, and hope to lengthen this sample period as soon as the data (particularly for fuel costs) are available.

We introduce a dummy variable for the month of September 2000 in some of our regressions based on PSP. Capacity payments in this month averaged £20.28/MWh, the third-highest monthly level in the Pool's history, yet September is a month of low demand. Ofgem's investigation (Ofgem, 2000) revealed that the high level of capacity payments was due to the way in which the Pool's algorithms had treated the particular mix of plant available to the system during that month, rather than due to any withholding by generators. It is arguable that a month of "freak" prices of this kind, occurring at a time of relatively low concentration, will tend to bias down our estimates of the true impact of concentration, and raise our estimate of the impact of NETA, since the prices were neither sought, nor directly caused, by the generators. The counter-argument is that the abolition of the Pool was expressly intended to ensure that we never again suffer from freak prices, and that a true assessment of the effectiveness of different measures to reduce prices must take account of the Pool's enduring ability to produce anomalous results. We therefore report results both with and without the dummy variable.

Bower (2002) uses data on concentration in different plant types, and the price of several different fuels, as his independent variables, together with a number of variables to reflect regulatory interventions between 1990 and 2002. Most of these are dummy variables, but he also uses the volume of coal covered by government-backed contracts between 1990 and 1998. He adopts a general to specific methodology, deleting variables that turn out to be insignificant.[9] He finds that changes in concentration, and in particular the divestment of coal plant, had a large impact on prices, that PSP was reduced by the introduction of NETA (because Capacity Payments were abolished), but that SMP apparently rose. He concludes that the costs of introducing NETA outweighed the benefits, given that capacity disposals could have been accomplished at a relatively low cost, and assuming that Capacity Payments might have been cheaply abolished while leaving the rest of the Pool's arrangements intact.

[8] It is not equal to the ratio between available capacity (controlling for strategic behaviour) and peak demand during the month, which would form the basis for our "ideal" regressor, but should be closely related to it.

[9] The Price Undertakings of 1994-6 (which reduced SMP), and the gas moratorium of December 1997-October 2000 (which raised PSP), together with the volume of coal contracts, were regulatory dummies that proved significant in the regressions most comparable to ours.

5. RESULTS – A STATIC VIEW OF NETA

Our first hypothesis was that the introduction of NETA might have caused a change in the level of the Lerner index, at the time that the rules changed. Using a static model of the market for a non-storable commodity, we would not expect a spillover from a future change in market rules to current prices. On this basis, a dummy variable set to 1 from April 2001 onwards should capture the impact of NETA.[10] As stated earlier, our dependent variables are Lerner indices, and we calculate these for SMP (plus its successor, the UKPX Reference Price Data) and for PSP (plus the overall cost of electricity in the post-NETA period). Our estimating regressions were:

$$SMPLerner = \alpha + \beta_1 \text{ Herfindahl} + \beta_2 \text{ Herfindahl}^2 + \beta_3 \text{ Demand/Capacity} + \beta_4 \text{ NETA}$$

$$PSPLerner = \alpha + \beta_1 \text{ Herfindahl} + \beta_2 \text{ Herfindahl}^2 + \beta_3 \text{ Demand/Capacity} + \beta_4 \text{ NETA}$$

and

$$PSPLerner = \alpha + \beta_1 \text{ Herfindahl} + \beta_2 \text{ Herfindahl}^2 + \beta_3 \text{ Demand/Capacity} + \beta_4 \text{ NETA} + \beta_5 \text{Sept00}$$

We used Generalised Least Squares in Shazam to account for serial correlation. Our results (table 1) show that both the Herfindahl index and its square are highly significant in

Table 1: Regression results on Lerner indices

	SMP (April 96-September 02)			PSP (April 96-September 02)			PSP (April 96-September 02) With Sept 2000 dummy		
	Coefficient	SE	P-value	Coefficient	SE	P-value	Coefficient	SE	P-value
Constant	-0.9234	0.3314	0.0068	-0.6018	0.3412	0.0820	-0.5433	0.3185	0.0924
Herfindahl	12.2250	3.8551	0.0022	11.2170	3.9602	0.0060	10.1310	3.7038	0.0078
Herfindahl ^{2}	-39.3990	13.609	0.0050	-38.7230	14.139	0.0077	-34.6440	13.224	0.0107
Demand / Capacity	0.7310	0.2839	0.0121	0.5475	0.2976	0.0699	0.5554	0.2773	0.0489
Neta*	0.0619	0.0631	0.3292	-0.0422	0.0632	0.5064	-0.0439	0.0589	0.4584
Sept 2000							0.2548	0.0709	0.0006
Adjusted R^2	0.6511			0.5831			0.6416		
SSE	0.3729			0.5114			0.4336		
Durbin-Watson	1.6148			1.7242			1.7355		
Akaike (1974)-AIC	0.0054			0.0075			0.0065		
Schwarz (1978)- SC	0.0063			0.0087			0.0078		
Sample Size	78			78			78		

*Dummy from April 2001

[10] We used data for the period up to 26 March 2001, the last day of the Pool's operation, for our final month of "Pool" prices, and discarded the first five days of prices under NETA, which might have been heavily affected by participants' learning.

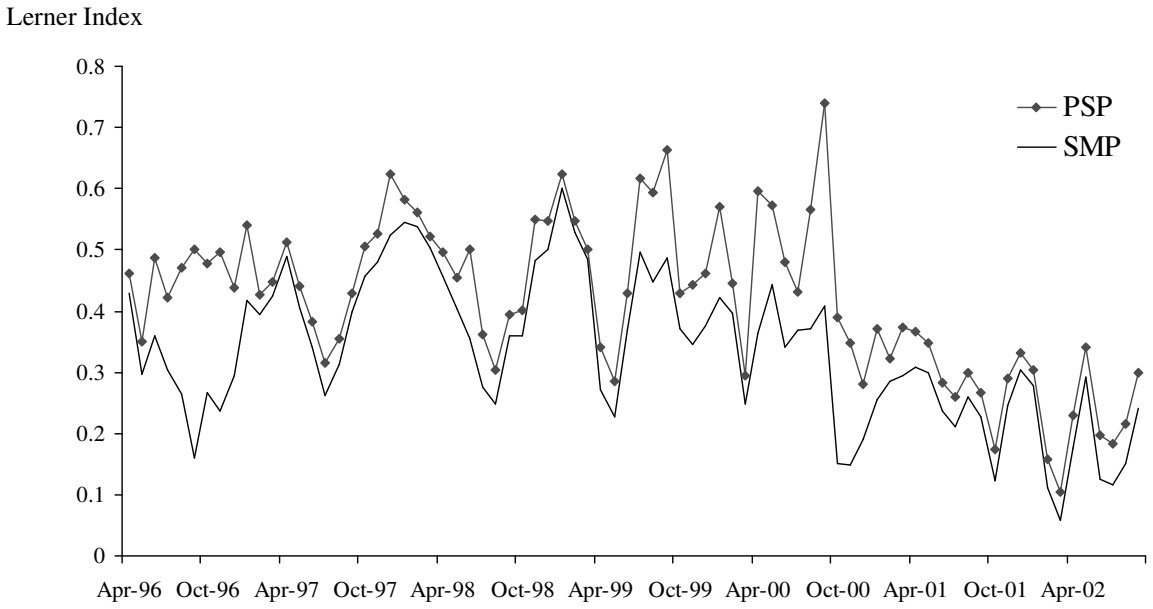


Figure 2

explaining the level of electricity prices, as expected. The ratio of demand to capacity is significant at the 5% level in explaining the Lerner index for SMP, but is only significant at 10% in explaining the Lerner index for PSP. This might seem surprising, since PSP incorporates the capacity payments that were intended to reflect the level of spare capacity on the system – however, remember that we use the level of registered capacity, as opposed to capacity actually available in a given month, which could affect the results. Furthermore, we have already commented on the ability of the capacity payment mechanism to produce counter-intuitive results at times.

We find that the dummy variable for NETA is insignificant in all three regressions. It is positive in the regression for SMP (a result which we regard as random noise, since we had no strong "prior" that the move to NETA would raise the level of prices) and negative in the regressions for PSP. The level of the latter coefficient, of –0.04, equates to a reduction in the price of electricity of about £1.20/MWh, given the level of marginal cost and the Lerner index prevailing at the end of the 1990s. The one component of the Pool Selling Price that was eliminated with the switch to NETA was the Capacity Payment, and this averaged £2.78/MWh over the last three years of the Pool's life. We note that given the level of spare capacity on the system at that time, the marginal value of capacity (which Capacity Payments were intended to reflect) was almost certainly well below that figure. We can also measure the impact of the changes in concentration and spare capacity between 1997/8 and 2001/2, on a similar basis. The Herfindahl index fell from approximately 0.16 to 0.08, which would have reduced SMP by £6.31/MWh and PSP by £5.78/MWh, based on a marginal cost of £13/MWh. The demand/capacity ratio fell from 0.55 to 0.50, which was sufficient to reduce

SMP by £1.36/MWh and PSP by £1.35/MWh. It is slightly surprising that the price including capacity payments appears to be no more affected by the level of spare capacity connected to the system, but we have already commented on the flaws of Capacity Payments.

6. RESULTS – A DYNAMIC VIEW OF NETA

Our results so far are consistent with those of Bower (2002), and in line with the theoretical arguments that suggested NETA would not have a significant impact on the price of electricity, apart from the direct effect of abolishing capacity payments. However, a visual inspection of our data (figure 2) reveals an obvious fall in the Lerner indices in October 2000, six months before the introduction of NETA. Neither of our main explanatory variables changes dramatically at this time, although the Herfindahl index does dip below 0.1 for the first time. This was due to the last of PowerGen's plant sales, and National Power's demerger.

A possible explanation for this drop in the Lerner indices may come from a more "dynamic" view of the electricity market. Recall that Sweeting (2001) had found evidence of behaviour consistent with tacit collusion during the late 1990s. Such behaviour normally depends upon how participants see the future of their market – tacit collusion implies giving away the present profits that would come from less collusive behaviour, which is only sensible if the participants believe that continued collusion can bring them greater future profits. If the generators believed that they would not be able to maintain a collusive equilibrium after the introduction of NETA, then they might have had to abandon any tacitly collusive practices once NETA drew near. The extra profit that they could have gained from only a few more months of tacit collusion was no longer enough to outweigh the immediate profits from more competitive behaviour. We therefore ran a new set of regressions, with a separate dummy variable for the "pre-NETA" period of October 2000 to March 2001.

The Herfindahl index is not significant at any level in any of these regressions, although the impact of the ratio of demand to capacity is hardly changed. The dummy variable for NETA is now negative in all our regressions, and significant in the second regression for PSP. The dummy for the six-month period preceding NETA is larger and more significant than the NETA dummy, which we find slightly worrying. Admittedly, the autumn of 2000 saw an increase in marginal costs, which might not have been fully passed through to prices. In general, though, there was no reason to expect that anticipation of NETA would actually drive mark-ups below the level that would be sustained under NETA itself. F-tests revealed that the coefficients on the two dummy variables were not significantly different from each other. We therefore consolidated the two dummy variables into a single variable, "para-NETA", equal to one from October 2000 onwards.

As before, the Herfindahl index is insignificant, while the ratio of demand to capacity is largely unaffected by the choice of the dummy variable. The new dummy variable for the period leading up to and after NETA is negative and highly significant in all three regressions. The reductions in concentration reduced SMP by £0.71/MWh and PSP by £1.25/MWh. The lower ratio of demand to capacity reduced SMP by £1.08/MWh and PSP by £1.40/MWh, while the introduction of NETA appears to have reduced SMP by £4/MWh and PSP by £4.86/MWh.

Table 2: Regression results on Lerner indices

	SMP (April 96- September 02)			PSP (April 96- September 02)			PSP (April 96- September 02) With Sept 2000 dummy		
	Coefficient	SE	P-value	Coefficient	SE	P-value	Coefficient	SE	P-value
Constant	-0.3758	0.3660	0.3080	-0.0033	0.3692	0.9929	-0.1041	0.3449	0.7637
Herfindahl	4.9940	4.4383	0.2642	2.9880	4.5151	0.5102	4.3416	4.2296	0.3081
Herfindahl ^{2}	-17.6960	14.968	0.2410	-13.3160	15.447	0.3915	-16.8170	14.461	0.2488
Demand / Capacity	0.7967	0.2696	0.0042	0.6399	0.2803	0.0254	0.5899	0.2603	0.0265
Pre-Neta†	-0.1926	0.0707	0.0081	-0.2232	0.0716	0.0026	-0.1526	0.0702	0.0332
Neta*	-0.0914	0.0802	0.2583	-0.2017	0.0772	0.0110	-0.1602	0.0725	0.0305
Sept 2000							0.2057	0.0753	0.0079
Adjusted R^2	0.6785			0.6274			0.6574		
SSE	0.3389			0.4509			0.4088		
Durbin-Watson	1.6624			1.7400			1.7649		
Akaike (1974) -AIC	0.0051			0.0067			0.0063		
Schwarz (1978)- SC	0.0061			0.0081			0.0077		
Sample Size	78			78			78		

†Dummy from October 2000 – March 2001
* Dummy from April 2001

Table 3: Regression results on Lerner indices

	SMP (April 96- September 02)			PSP (April 96- September 02)			PSP (April 96- September 02) With Sept 2000 dummy		
	Coefficient	SE	P-value	Coefficient	SE	P-value	Coefficient	SE	P-value
Constant	-0.1196	0.3357	0.7227	0.0534	0.3284	0.8714	-0.1240	0.3154	0.6953
Herfindahl	2.8919	4.3059	0.5039	2.5288	4.2624	0.5548	4.5039	4.0762	0.2729
Herfindahl ^{2}	-11.0060	14.591	0.4531	-11.7590	14.635	0.4243	-17.3640	13.946	0.2171
Demand / Capacity	0.6214	0.2509	0.0156	0.5953	0.2495	0.0196	0.6054	0.2344	0.0118
Para-Neta *	-0.1615	0.0690	0.0221	-0.2137	0.0658	0.0018	-0.1557	0.0649	0.0190
Sept 2000							0.2041	0.0741	0.0075
Adjusted R^2	0.6709			0.6319			0.6621		
SSE	0.3517			0.4515			0.4088		
Durbin-Watson	1.6572			1.7415			1.7650		
Akaike (1974) -AIC	0.0051			0.0066			0.0061		
Schwarz (1978)- SC	0.0060			0.0077			0.0073		
Sample Size	78			78			78		

* Dummy from October 2000

We therefore seem to have two conflicting hypotheses on the impact of NETA. Our

"static" regression suggests that NETA had little impact on prices, and that the reduction was largely due to increasing competition and additional capacity. Our "dynamic" story suggests that the increases in competition had failed to reduce prices, but that the imminent prospect of new trading rules that allowed prices to fall. The standard statistical criteria (adjusted R-squared, Akaike (1974) Information Criterion and Schwarz (1978) Criterion) all favour the regressions from table 3.

A number of commentators have suggested other factors that could have affected electricity prices from October 2000 onwards. Chief among these is the suggestion that National Power and PowerGen would 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. This would give a step change in mark-ups at the critical time.

An alternative version of the dynamic story is that generators faced with an imminent rise in competition would be able to continue colluding, but not to the same extent. Lower prices would reduce the gain from defection, bringing it down to the decreasing punishment that could be imposed in the remaining life of the Pool. This would produce a gradual decline in prices, rather than the sudden drop we observe.

Another possible cause of a sudden drop in prices might be the end of the gas moratorium, since Bower's results pointed its importance in raising prices. One hypothesis is that the incumbents felt free to charge more while the moratorium protected them from entry. However, the moratorium did not prevent entrants from planning new stations and signing Connection Agreements with NGC,[11] in readiness for construction once it was lifted. The incumbents were still protected from immediate entry after the end of the moratorium, given the time required to build a new station. A further set of regressions (available from the authors) did not find a significant coefficient for a dummy variable covering the moratorium period.

7. CONCLUSION

The results presented in table 1 and table 3 give very different impressions of the impact of NETA. Table 1 is consistent with the warnings given by a number of economists in the run-up to the change in trading arrangements, who argued that changing the market rules would have little impact on prices, and that the main hope for lower prices would come from greater competition. Additional capacity had some effect on prices, but the main reductions were indeed due to reductions in concentration. This interpretation is based on the idea that since electricity is a non-storable commodity, the price for March delivery cannot depend on events expected to take place in April.

The counter-argument relies on the hypothesis that generators might have been engaging in tacit collusion in the late 1990s, but that they became unable to sustain this a few months before the introduction of NETA, once there was no longer a sufficient period in which "punishment" strategies could be imposed. If this argument is accepted, then it is legitimate to look for price effects in anticipation of the change in trading rules, and we do indeed find a dramatic reduction in mark-ups six months before the abolition of the Pool. Conversely, the reductions left to be explained by increased competition and spare capacity are much lower, and so these appear to be far less effective in bringing prices down.

[11] NGC(1999) reports that 5 GW of plant was contracted for future entry during 1998/9.

We are currently inclined to support this second hypothesis. The regressions are a better fit to the data, and Sweeting (2001) gives convincing evidence of tacit collusion for much of the critical period, although his work stops tantalisingly short, in September 2000. As the introduction of NETA drew near, could the generators have realised that they were in a finitely repeated game, and believed that they would not be able to maintain high prices under the new trading rules? If so, they would have had every reason to switch from a high-price to a low-price equilibrium, even while still trading through in the Pool. Some anecdotes within the industry are consistent with this view, although others suggest that the generators chose a lower price strategy because they were no longer selling plant. An examination of the bid data around this time would show which companies changed their strategies, and might allow us to better discriminate between explanations for the fall in prices.

A number of academic economists (including one of us) had suggested that NETA would not necessarily be less vulnerable to high prices than the Pool-based system. If our tentative explanation for the fall in margins that preceded NETA is indeed correct, it is perhaps fortunate for consumers that the companies appear not to have listened to them.

References

Akaike, H. (1974) "A new look at the statistical identification model" *IEEE: Trans. Auto. Control*, vol. 19, pp 716-23

Bower, J. (2002) "Why did electricity prices fall in England & Wales: Market mechanism or market structure?" Working Paper EL02, Oxford Institute for Energy Studies

Bower, J. and D.W.Bunn (2000) "Model-based comparisons of Pool and Bilateral Markets for Electricity" *The Energy Journal*, vol 21 no 3 pp 1-29

Fabra, N. (2002) "Tacit Collusion in Repeated Auctions: Uniform versus Discriminatory", *Journal of Industrial Economics*, forthcoming

Fabra, N., N-H M. von der Fehr, and D. Harbord (2002) *Designing Electricity Auctions: Uniform, Discriminatory and Vickrey*, mimeo, Universidad Carlos III, Madrid

von der Fehr, N-H M., and D. Harbord (1993) "Spot Market Competition in the UK Electricity Industry", *Economic Journal*, vol 103 no 418 pp 531-46

Green, R.J. (1999a) "Draining the Pool: The Reform of Electricity Trading in England and Wales", *Energy Policy* Vol 27 No 9, pp. 515-525

Green, R.J. (1999b) "The Electricity Contract Market in England and Wales" *Journal of Industrial Economics*, Vol XLVII, No 1, pp.107-124

Green R.J., and D..M..Newbery (1992) "Competition in the British Electricity Spot Market" *Journal of Political Economy* 100 (5), October, pp 929-53

Green, R.J. and D..M..Newbery (1997) "Competition in the Electricity Industry in England and Wales" *Oxford Review of Economic Policy* Vol 13 No 1, pp 27-46

Newbery, D.M. (1998a) "Competition, contracts and entry in the electricity spot market", *RAND Journal of Economics*, vol 29 no 4 pp 726-749

Newbery, D.M. (1998b) "The Regulator's Review of the English Electricity Pool" *Utilities Policy*, vol 7 no 3, pp.129-142

NGC (1999) *1999 Seven Year Statement* Coventry, National Grid Company

Offer (1998) *Review of Electricity Trading Arrangements: Proposals, July 1998* Birmingham, Office of Electricity Regulation

Ofgem (2000) *No action against generators after unplanned outages*, Press Notice 109, 13 October 2000, London, Office of Gas and Electricity Markets

Powell, A. (1993) "Trading Forward in an Imperfect Market: The Case of Electricity in Britain", *Economic Journal*, Vol 103, No 417, March pp 444-53

Schwarz, H. (1978) "Estimating the dimension of a model" *The Annals of Statistics* vol. 6, pp 461-4

Sweeting, A.T. (2001) *Market Outcomes and Generator Behaviour in the England and Wales Wholesale Electricity Market,* mimeo, MIT

Wolak, F. (2000) "An Empirical Analysis of the Impact of Hedge Contracts on Bidding Behavior in a Competitive Electricity Market", *International Economic Journal,* vol 14 no 2, pp 1-40

Wolfram, C.D. (1998) "Strategic bidding in a multiunit auction: an empirical analysis of bids to supply electricity in England and Wales", *Rand Journal of Economics*, vol 29, no 4, pp 703-725

Wolfram, C.D. (1999) "Measuring Duopoly Power in the British Electricity Spot Market", *American Economic Review*, vol 89 no 4, pp 805-826