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Abstract

In an attempt to reduce high electricity prices in England and Wales the government has tried to encourage an increase in generation capacity, introduced a more competitive market structure and changed the market rules. Our econometric analysis on monthly data from April 1996 to March 2002 implies support for two conflicting hypotheses. On a static view, increases in competition and the capacity margin were responsible for the fall in prices, while changes in the trading rules had little impact. 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. Regressions representing this hypothesis imply that NETA was responsible for a significant part of the reductions in prices after 1998.

Key words

Electricity, market power, concentration, market rules

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These results are provisional – please check before citing.

Non-technical summary

In an attempt to reduce high electricity prices in England and Wales the government has tried to encourage an increase in generation capacity, introduced a more competitive market structure and changed the market rules. 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 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. In this paper, concentration is measured by the Herfindahl index for overall capacity ownership, summing the squared shares of capacity. The Lerner index (price minus marginal cost, divided by price) is used to measure mark-ups. 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) are used. Since NETA, the closest equivalent to Pool prices is the UKPX's Reference Price Data. When looking at SMP, we use the UKPX price on its own as our post-NETA price. When looking at PSP, we add the costs of transmission and system balancing.

Our econometric analysis from April 1996 to March 2002 implies support for two conflicting hypotheses, although the models based on the second of these fit the data slightly better.

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. This was supported by our 'static view' that implies that increases in competition and the capacity margin were responsible for the fall in prices, while changes in the trading rules had little impact. This is also 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.

Our second hypothesis is prompted by the finding of Sweeting (2001) of 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 future profits. If the generators believed that they would not be able to maintain a collusive equilibrium after the introduction of NETA, then they would 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.

Regressions representing this hypothesis imply that NETA was responsible for a significant part of the reductions in prices after 1998. 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. Anecdotes within the industry are consistent with this view.

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, but using the generators' price bids in place of costs. The software had used information on start-up costs, the cost of running with no load, and the cost per MWh for up to three tranches of output, and so the bids into the Pool could contain up to five prices, together with many pieces of technical information. The National Grid Company then used this information to produce the (apparently) least-cost 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 Loss of Load Probability was the risk that demand would exceed available capacity, calculated from figures on demand, availability, and the available stations' past risk of becoming unavailable, while the Value of Lost Load was set at £2/kWh in 1990, and uprated with inflation annually. For stations scheduled to generate,[1] the net Value of Lost Load was equal to VOLL less SMP, so that the Pool Purchase Price was equal to SMP x (1-VOLL) + LOLP x VOLL. This was paid for all the output in the Pool's main schedule.

In practice, there would be many deviations from the schedule. The Pool was unable to differentiate between deviations that had been instructed by NGC, and those that were not. It therefore paid all deviations at the generator's own bid price, treating each generator as if they had been instructed. The cost of these deviations, 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.

Legally, almost all electricity had to be traded through the Pool, although in practice, most of it was hedged with contracts for differences. The seller would reimburse the buyer if the Pool Purchase Price was greater than an agreed strike price, while the buyer would pay more to the seller if the Pool Purchase Price was low. This allowed generators to "lock in" their revenues in advance, although buyers were exposed to changes in Uplift, and hence the margin between the Pool Selling Price which they paid and the PPP which they could hedge.[2] 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. The regulator considered that the disposals were necessary to increase the amount of competition in the mid-merit part of the industry. A number of new Combined Cycle Gas Turbine (CCGT) stations were under construction or in commission, and improving performance by the nuclear power stations meant that the base load segment of the market was becoming increasingly competitive, but National Power and PowerGen continued to set the SMP about 90 per cent of the time. The Eastern leases were intended to

[1] Stations that were not scheduled to generate received a capacity payment equal to SMP minus their own bid price, multiplied by LOLP.
[2] This is a description of a "two-way" contract for differences; some "one way" contracts only involved payments if the Pool Purchase Price was high.

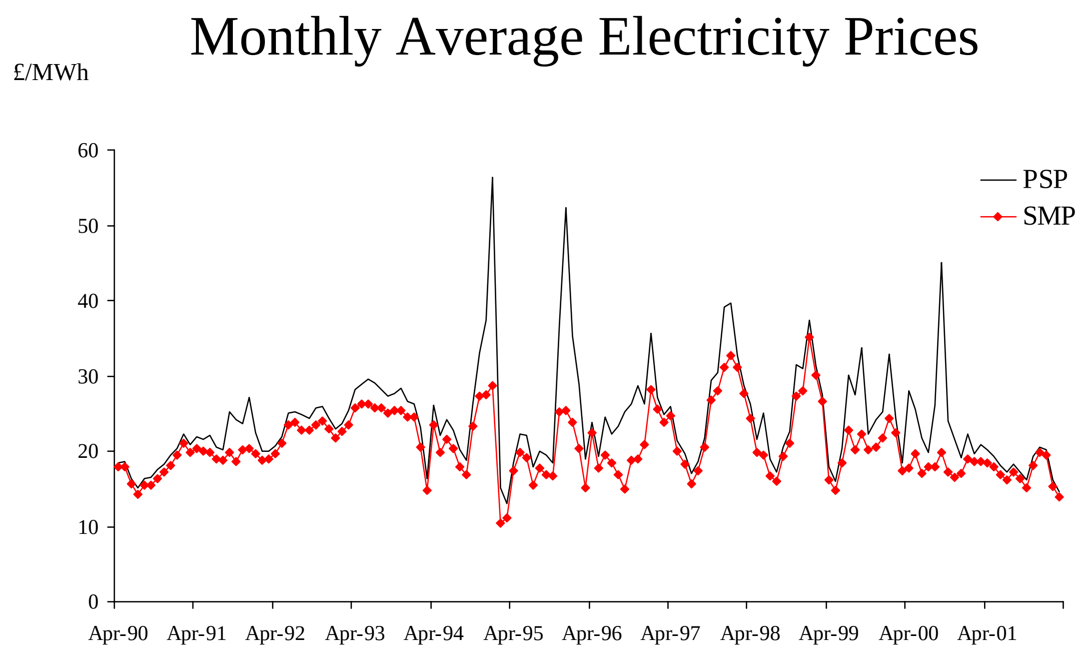

Figure 1

reduce their dominance, but had a limited effect. 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.[3] 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

[3] 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.

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.

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.[4]

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, and it is to this work that we now turn.

[4] 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. 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. Prices would be lower in a less concentrated industry, and they suggested that a five-firm structure in England and Wales would have produced a better outcome than the duopoly actually adopted. 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. Green and Newbery did not explicitly draw a link between spare capacity and the level of prices, although the relationship is implicit in their diagrams of supply function equilibria.

Figure 2, taken from Green and Newbery (1997), shows the range of supply function equilibria for an industry divided into two firms, and for one divided into five. Moving along the steepest supply functions, the price-cost margin rapidly increases with the level of output. Moving along the lowest supply functions, however, the price-cost margin will eventually fall, as these supply functions approach the marginal cost curve where it intersects the highest level of demand that the firms might encounter.

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[5] 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. Newbery suggests that incumbent generators could use contracts to commit themselves to keep time-weighted average prices at an entry-deterring level, while increasing the variability of prices. Since the incumbents sold an above-average level of output at times of peak demand, this strategy would maximise their own revenues for a given level of time-weighted prices. 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-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

[5] 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.

Supply function ranges

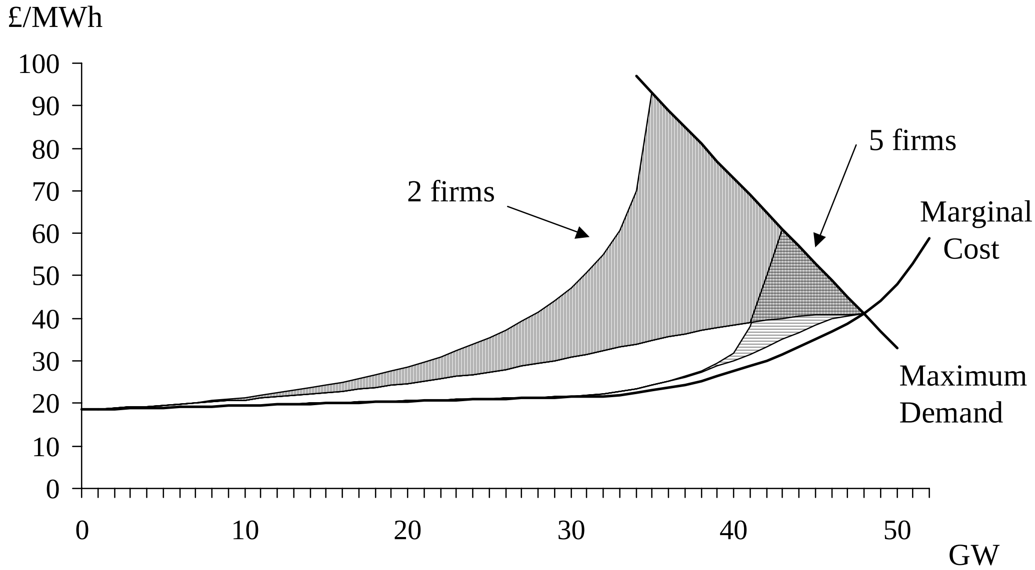

Figure 2 (from Green and Newbery, 1997)

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. We cannot be sure about the relationship between demand and mark-ups in a supply function model without contracts, given the multiplicity of equilibria, especially as the relationship within some of these equilibria is non-monotonic. Nevertheless, the empirical work reported earlier, and the theoretical conclusions of auction models, imply that we should expect higher mark-ups when demand is high relative to the level of capacity.

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,[6] 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.[7] A true picture of the costs that suppliers face under NETA would also include the costs of 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. 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

[6] 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.

[7] 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.

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.[8] 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 (price minus 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-setting) firms is linear, most supply functions are non-linear. Figure 2 furthermore 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.[9]

We have 72 monthly observations from April 1996 until March 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 only have one year 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.

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[8] 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.

[9] 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.

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.[10] 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.

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 2000 onwards should capture the impact of NETA.[11] 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:

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

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

and

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

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 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.

[10] 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.

[11] 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.

Table 1: Regression results on Lerner indices, full sample

	SMP (April 96-March 02)			PSP (April 96-March 02)			PSP (April 96-March 02) With Sept 2000 dummy		
	Coefficient	SE	P-value	Coefficient	SE	P-value	Coefficient	SE	P-value
Constant	-1.0774	0.3748	0.0054	-0.6439	0.3789	0.0939	-0.5885	0.3541	0.1013
Herfindahl	13.966	4.3766	0.0022	11.689	4.3993	0.0098	10.627	4.1182	0.0121
Herfindahl ^{2}	-44.048	15.086	0.0048	-39.961	15.551	0.0124	-35.994	14.546	0.0159
Demand / Capacity	0.7381	0.2972	0.0155	0.5469	0.3203	0.0923	0.5584	0.2982	0.0655
Neta	0.0489	0.0662	0.4628	-0.0626	0.0656	0.3435	-0.0621	0.0614	0.3154
Sept 2000							0.2539	0.0707	0.0006
Adjusted R^2	0.6277			0.5150			0.5882		
SSE	0.3363			0.4925			0.4119		
Durbin-Watson	1.6263			1.7218			1.7317		
Akaike (1974)-AIC	0.0054			0.0079			0.0068		
Schwarz (1978)- SC	0.0063			0.0092			0.0082		
Sample Size	72			72			72		

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 –0.06, equates to a reduction in the price of electricity of about £2/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 £7.50/MWh and PSP by £6/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 £1.50/MWh and PSP by £1.30/MWh. It is slightly surprising that the price including capacity payments appears to be less affected by the level of spare capacity connected to the system, but we have already commented on the flaws of Capacity Payments.

When we inspected the data, we observed that the Lerner indices were relatively low in the first year of our sample, which also saw the highest levels of concentration. Prices in this period *might* have been atypical, if the major generators were adjusting to the forced disposal of some of their capacity, learning how Eastern would bid, and concerned to avoid high prices that might trigger the re-imposition of the Price Undertakings of 1994-96. We therefore re-ran our regressions on the truncated period from April 1997 to March 2002. The impact of changes in concentration was at least twice as strong, while the impact of NETA on PSP was more than halved. The new results (see table 2) do not change the overall picture, however.

Table 2: Regression results on Lerner indices, part sample

	SMP (April 97- March 02)			PSP (April 97- March 02)			PSP (April 97- March 02) With Sept 2000 dummy		
	Coefficient	SE	P-value	Coefficient	SE	P-value	Coefficient	SE	P-value
Constant	-1.8705	0.6605	0.0065	-1.9597	0.7888	0.0160	-1.4066	0.7372	0.0617
Herfindahl	26.314	9.8305	0.0098	31.32	11.573	0.0090	22.795	10.826	0.0399
Herfindahl ^{2}	-92.126	38.349	0.0197	-116.41	44.946	0.0123	-83.571	42.008	0.0517
Demand / Capacity	0.8631	0.3174	0.0087	0.7822	0.3932	0.0516	0.7160	0.3615	0.0527
Neta	0.0777	0.0652	0.2381	-0.0168	0.0802	0.8350	-0.0141	0.0741	0.8499
Sept 2000							0.2327	0.0745	0.0029
Adjusted R^2	0.6823			0.5534			0.6145		
SSE	0.2573			0.4329			0.3668		
Durbin-Watson	1.5109			1.6744			1.6654		
Akaike (1974) – AIC	0.0051			0.0085			0.0075		
Schwarz (1978)- SC	0.0060			0.0101			0.0092		
Sample Size	60			60			60		

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 3) 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 significantly at this time, although the Herfindahl index does dip below 0.1 for the first time. We do not propose to build an explanation around the kind of "threshold effect" that would be needed for this to have an important impact, however.

A possible explanation for this drop 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 would 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

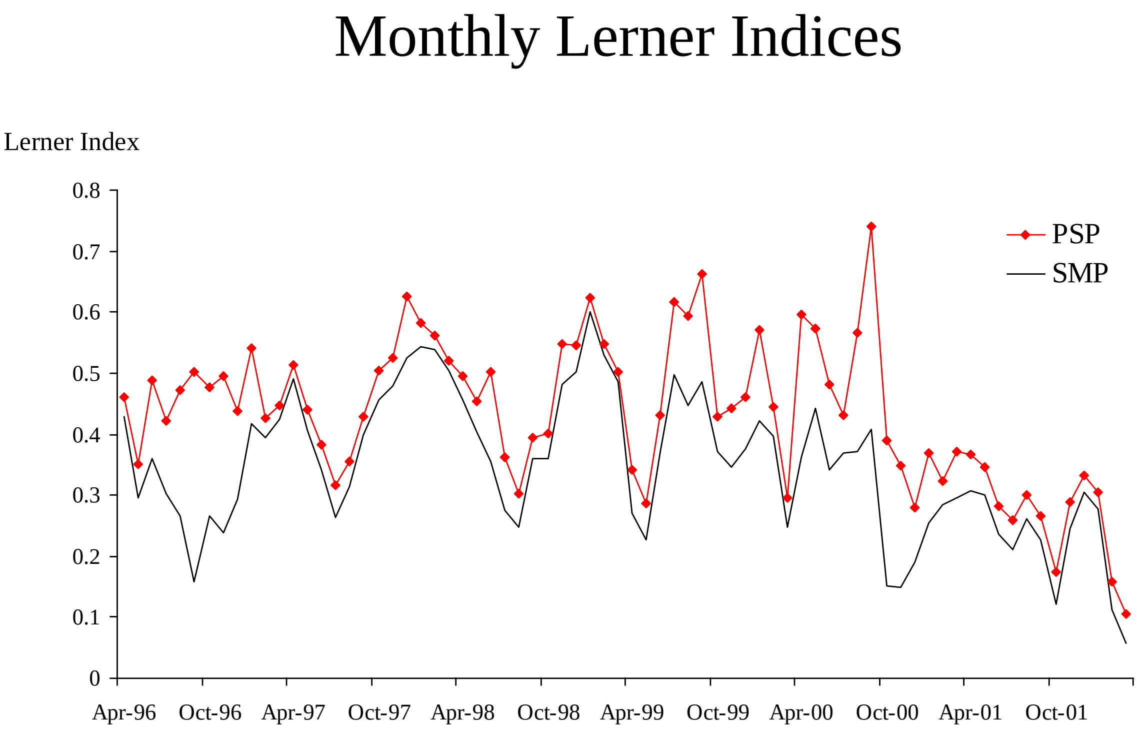

Figure 3

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 and the ratio of demand to capacity reduced both SMP and PSP by about £3/MWh, while the introduction of NETA appears to have reduced SMP by £4/MWh and PSP by £5/MWh.

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, and it was only the imminent prospect of new trading rules that allowed prices to fall. We can compare the original data with the estimates from two regressions for the Lerner index based on SMP in figure 4, and with the estimates from two regressions for the Lerner index based on PSP in figure 5. The regressions are taken from table 1 and table 4, and we use the regressions in the third column (i.e., including the dummy variable for September 2000) for the Lerner index based on PSP.

In figure 4, we see that both regressions perform similarly for the first three years of the sample, but that the para-NETA regression is then closer to the data during 1999-2000. The NETA regression line moves down, reflecting the reduction in concentration at this time, but prices remained high for a further year. In 2001/2, however, the regression with a dummy variable for NETA is closer to the data than the regression based on the para-NETA dummy.

Table 3: Regression results on Lerner indices, full sample

	SMP (April 96- March 02)			PSP (April 96- March 02)			PSP (April 96- March 02) With Sept 2000 dummy		
	Coefficient	SE	P-value	Coefficient	SE	P-value	Coefficient	SE	P-value
Constant	-0.4692	0.3950	0.2391	-0.0430	0.3992	0.9145	-0.1210	0.3692	0.744
Herfindahl	6.0633	4.7577	0.2070	3.3185	4.8510	0.4963	4.5065	4.506	0.321
Herfindahl ^{2}	-20.975	15.828	0.1897	-14.523	16.507	0.3822	-17.369	15.34	0.262
Demand / Capacity	0.8202	0.2812	0.0048	0.6759	0.3021	0.0286	0.5998	0.2792	0.035
Neta	-0.1155	0.0819	0.1631	-0.2174	0.0777	0.0067	-0.1758	0.0719	0.017
Pre-NETA	-0.2040	0.0709	0.0055	-0.2373	0.0735	0.0019	-0.1595	0.0724	0.031
Sept 2000							0.1991	0.0759	0.011
Adjusted R^2	0.6630			0.5748			0.6085		
SSE	0.2999			0.4253			0.3857		
Durbin-Watson	1.6785			1.7373			1.7548		
Akaike (1974) -AIC	0.0049			0.0070			0.0065		
Schwarz (1978)- SC	0.0059			0.0084			0.0081		
Sample Size	72			72			72		

Table 4: Regression results on Lerner indices, full sample

	SMP (April 96- March 02)			PSP (April 96- March 02)			PSP (April 96- March 02) With Sept 2000 dummy		
	Coefficient	SE	P-value	Coefficient	SE	P-value	Coefficient	SE	P-value
Constant	-0.2818	0.3742	0.4541	0.0058	0.3702	0.9876	-0.1571	0.3534	0.6581
Herfindahl	4.6213	4.679	0.3269	2.9403	4.6740	0.5314	4.7776	4.4504	0.2870
Herfindahl ^{2}	-16.555	15.623	0.2931	-13.246	15.950	0.4092	-18.280	15.147	0.2318
Demand / Capacity	0.6885	0.2668	0.0121	0.6353	0.2762	0.0246	0.6307	0.2591	0.0176
Para-Neta	-0.1783	0.0691	0.0121	-0.2274	0.0662	0.0010	-0.1673	0.0654	0.0129
Sept 2000							0.1953	0.0744	0.0107
Adjusted R^2	0.6582			0.5806			0.6141		
SSE	0.3088			0.4259			0.3860		
Durbin-Watson	1.6699			1.7371			1.7554		
Akaike (1974) -AIC	0.0049			0.0068			0.0063		
Schwarz (1978)- SC	0.0058			0.0080			0.0077		
Sample Size	72			72			72		

Using statistical criteria, the regression from table 4 clearly out-performs that from table 1: it has a higher adjusted R-squared (0.6582 versus 0.6277), and lower values of the Akaike

Comparison of the SMP regressions

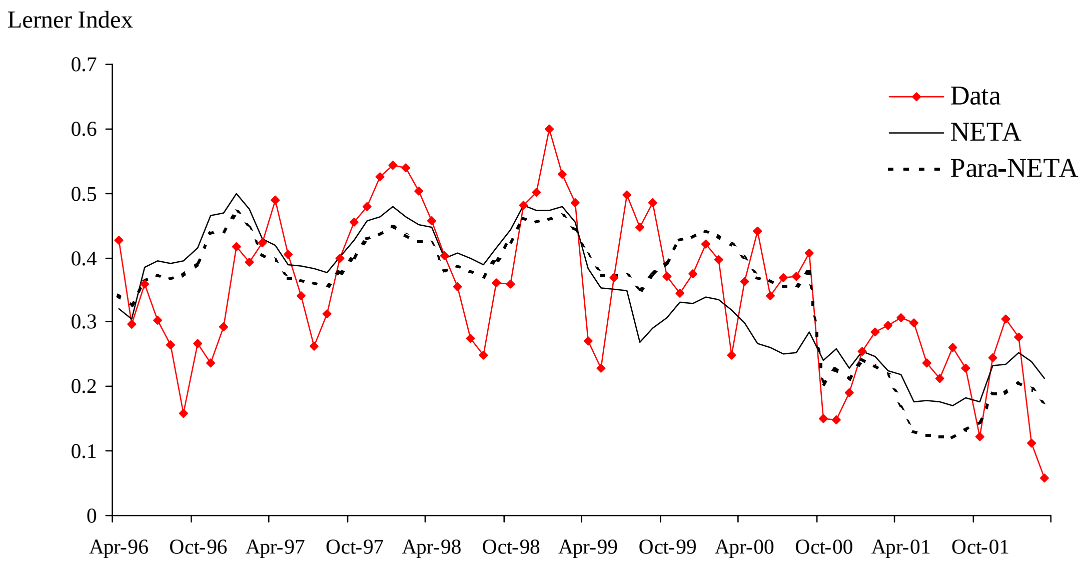

Figure 4

(1974) Information Criterion (0.0049 versus 0.0054) and Schwarz (1978) Criterion (0.0058 versus 0.0063).

In figure 5, the two regressions again track each other closely until the middle of 2000, and it appears that the regression based on the para-NETA dummy once again is closer to the data for the following year. Furthermore, the regression line is also closer to the data in the post-NETA period. Once again, the standard statistical criteria favour the regression from table 4: a higher adjusted R-squared (0.6141 against 0.5882), and lower values of the Akaike (1974) Information Criterion (0.0063 versus 0.0068) and Schwarz (1978) Criterion (0.0077 versus 0.0082).

7. CONCLUSION

The results presented in table 1 and table 4 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.

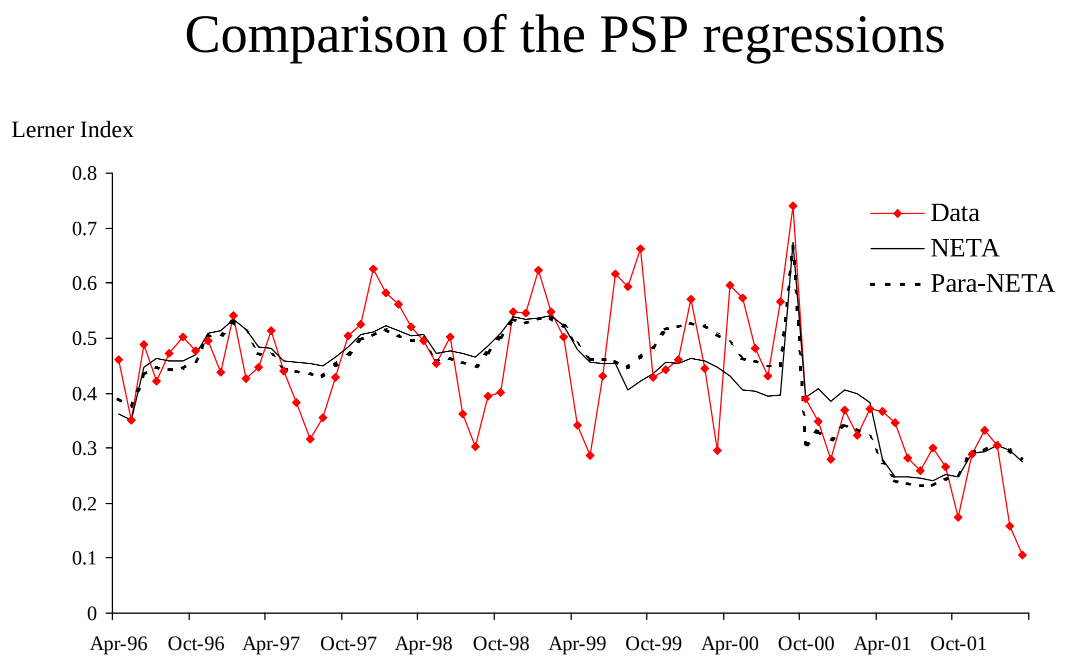

Figure 5

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.

We are currently inclined to support this second hypothesis, although we plan to extend our data set and see if the results change. 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. Anecdotes within the industry are consistent with this view. 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.

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