Understanding the Performance of the Electric Power Industry in China*

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Abstract
Despite three decades of reform, China's electricity sector is still organized by a "new reformed plan" where capacity investment has been liberalized but prices and production remain controlled. This paper examines the impact of the current plan prices on end-users with reference to the OECD and how the plan price of electricity supply is formed. We argue that the plan price is set in an attempt to balance the interests of the public and the power industry. We find that China's industries do not pay a cheaper price for electricity than the West, and the plan price is formed through bargain between the firm and the state, which allows the firm to have a soft price constraint on its costs.

1. Introduction

Broadly speaking, since 1990, China's power generation sector has been liberalized gradually to both domestic private and state investment and to international investment as well. The generation sector consists mainly of state-owned or state-controlled companies, although private and foreign companies are given the access to invest in power generation (Rosen and Houser 2007; Kroeber, Lee, and Yao 2008). In 2007, the five largest central-government-directly-owned power corporations[1] had 43 percent of installed generating capacity compared with 40 percent of the capacity controlled by local govern-

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1 The largest five power corporations are Huaneng, Datang, Guodian, Huadian, and China Power International.

ments and 6 percent by private owners (SERC 2008). The largest five have been restructured since 2003, this enables them to list their subsidiaries in both domestic and Hong Kong stock markets to raise private capital in support of further investment in capacity. As a result of free entry into the industry, China installed new capacity (390 gigawatt hours [GWh]) in the 2002–07 period that was equivalent of more than three times the total capacity of Germany (Kroeber, Lee, and Yao 2008). China produces more than 500 billion GWh a year, making it the second largest electricity power producer in the world.

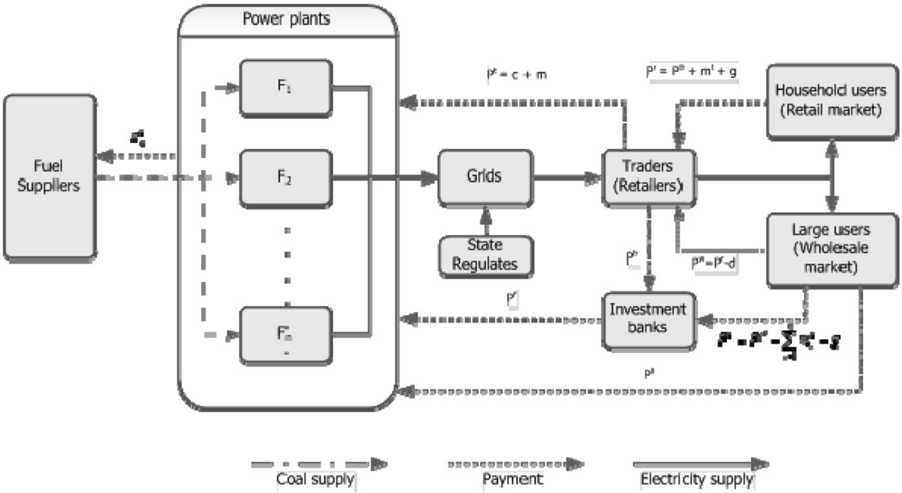
There has not been the same deregulation in the other parts of the electricity supply chain such as power distribution and retail sales, however. Once capacity is built up, the use of that capacity to generate power for sales has still been strictly regulated by the state (Liu 2006; Wang 2006). Besides the continued control on quantity produced, the National Development and Reform Commission (NDRC) also determines both the price at which generators can sell their power to the grid and the price that the grid can charge end-users (Rosen and Houser 2007). This partially liberalized system has been called the "new reformed plan system."

Currently, there are two regional power grid companies: the State Grid Corporation and the China Southern Power Grid. The state sets up "on-grid prices" to regulate power plants in selling their electricity to the grid company that has a regional monopoly that is in charge of both the high-voltage electricity transmission and the low-voltage distribution to a region. This regulated price for consumers is called a *catalogue price*. The grid company's profits are mainly determined by the difference between the on-grid price and the catalogue price.

Despite 30 years of economic reforms, why does China still use a state plan for its electric power sector? There are numerous academic studies as well as studies by commercial interests on China's electricity supply (e.g., Andrews and Dow 2000; Lam 2004; Bradley and Yang 2006; Wang 2006; Rosen and Houser 2007; Wang 2007). Our study will address the question through understanding a key issue of the industry—electricity pricing by the state.

This paper will discuss, institutionally, how the NDRC sets a basic plan price as guidance for the provincial development and reform commission to agree on a plan price with a local power producer. The price agreement is made through bargaining between two parties by considering the interest of government development policy, the cost of the power firm, and other conditions of the business. This price bargaining mechanism leads each firm to receive an individually tailored plan price for selling its power to the grid. The firm has an incentive to influence the local planner

Figure 1. The structure of the UK electricity market



Source: *Based on the information from "The Digest of United Kingdom Energy Statistics 2006."*

Note: p^c_m *= market price of the coal;* F_n *= the* n^{th} *power firm;* p^t *= the electricity price paid by traders to power firms;* p^r *= the electricity price paid by household users to power traders;* p^b *= the electricity price paid traders to investment banks;* p^w *= the wholesale electricity price paid by large users to traders;* p^f *= the electricity price paid by the investment banks to power firms through the future supply contracts;* p^l *= the electricity price paid by large users to power firms ; c = power firm's costs; m = the profit margin of the power firm;* m^t *= trader's premiums;* m^b *= bank's premiums; g = grid's costs; d = discount for large users.*

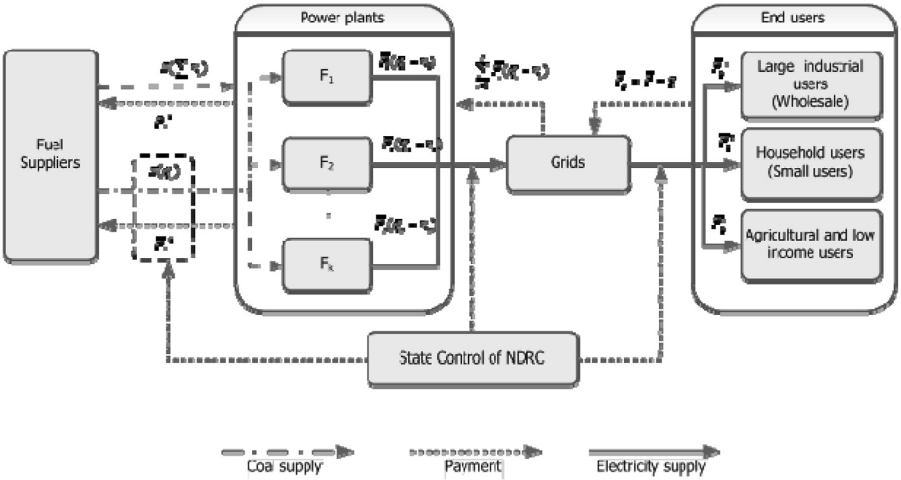
to set a plan price in the firm's favor. We argue that, as a result this new reformed plan system allows the firm to face a soft price constraint on its costs in a sharp contrast to the hard price constraint imposed by a perfectly competitive market.

We organize our analysis as follows. Section 2 highlights the structure of the Chinese electricity supply with reference to the United Kingdom (UK) as an example of full electricity market liberalization. Section 3 examines whether electricity is cheaper in China than in the OECD economies. Section 4 models the bargaining mechanism that sets the plan price. Section 5 tests our model using a panel sample of more than 110 power firms over 2003–05. Section 6 summarizes our findings and their economic implications.

2. Structure of China's power supply with reference to the UK

As a reference, we show the structure of the UK electricity supply in Figure 1. In contrast to the reference, China's supply structure is shown in Figure 2. Figure 1

Figure 2. The structure of electricity industry in China



Source: *Based on the information from Wang (2007) and China Electricity Market & Tariffs Monitoring Report 2005.*
Note: *$\bar{x}$ = the quantity of coal supply; n_i = the quantity of excessive power production of the i^{th} power firm; q_i = the plan output of the i^{th} power firm; p_i^c = the market coal price paid by the i^{th} power firm for excessive power production; $\bar{p}_i^c$ = the plan coal price paid by the i^{th} power firm; F_k = the k^{th} power firm; $\bar{p}_k$ = the plan price given to the k^{th} power firm to sell its produced electricity; $\bar{p}$ = the average plan electricity price; $\bar{p}_g$ = the average electricity price for end-users; g = grid's costs; p_g^w = the electricity price for large users; p_g^s = the electricity price for household users; p_g^i = the electricity price for agriculture and low income users.*

shows that the retail and the wholesale market are separated in the UK. In the wholesale market, any large-quantity buyers (this includes wholesale traders, large industry users, and even investment banks) can directly approach power firms to purchase electricity at a negotiated price. This institutional change is expected to stimulate direct competition between power firms in selling electricity to large buyers and also to households via retail traders. Because consumers are given a choice of their suppliers, competition is inevitable between power producers and also between retail traders in the resale of power to households.

In the Figure 1, $p^c{}_m$ is the price paid to coal producers by power producers or firms; F_n indicates an n^{th} power firm in the power generation sector; p^t is a trade price paid by large volume buyers, such as electricity traders, investment banks, and large industrial users, to power producers; p^b is a price paid by the traders for buying electricity from investment banks that hold power production through futures contracts with power producers; p^f is the fixed price of the futures contract paid by investment banks to power producers; p^r is a retail price paid by final household users to the traders; p^w is a wholesale price by large industrial users to the traders with

Table 1. Cost structure of UK electricity in 2002

	Percentage of price (%)		Costs and prices (£/kWh)		Percentage difference between Household and I&C[a]
	Household	I&C	Household	I&C	
Generation	40	60	0.035	0.026	26
Transmission	3	5	0.003	0.002	33
Distribution	25	24	0.022	0.010	53
Retail (supply)	26	11	0.023	0.005	79
Other	6	0	0.005	0.000	100
Price	100	100	0.087	0.043	51

Source: *Authors' own calculation on the basis of 1) "Gas and Electricity Price Projections," OXERA, 2004, 2) "The New Electricity Trading Arrangements in England and Wales," National Audit Office, 2002–03: 9 May 2003, pp. 19–20, and 3) "Electricity Information 2006," IEA.*

Note: *a. The percentage difference = (Household costs − Industrial & commercial costs) / Household costs.*
I&C = industrial & commercial users.

discount *d; c* is the marginal costs of producers and m is the profit margin added by producers on the costs; m^b is a profit margin charged by an investment bank in its price; and g is the marginal costs of transmission charged by the grid company.

The competitive structure of the UK is not built up without cost. One cost is the creation of an extra layer of trading (or the "middle men") between the end users and the power producers. The middle traders seek transaction premiums, denoted by m^t (trader's premiums) or m^b (bank's premiums) in Figure 1, in which the premiums could be higher if they are collusive in setting trade conditions. Moreover, recently, investment banks were brought into the power trading business to purchase power using a futures supply contract at a fixed price (p^f) paid to the power firms for a specified future time. Futures supply contracts are helpful in reducing income-stream uncertainty for power firms in the foreseeable future. They are costly for the end users or even other wholesale traders, however, who need to buy one from the bank at a higher price than the normal trade price (p^t) paid for the direct purchase of power, making $p^f > p^t$, since the futures price embeds the risk cost in price volatility. If a futures supply contract is resold to another bank with an expectation that the price will be higher, then one more margin will be added in the price, and if there are n runs of resale of the contract among banks, the final price paid by the trader or consumers can end up with a payment at

$$p^b = p^f + \Sigma m + g\,,$$

where g is the costs of the power grid. It is reported that some 90 percent of power in the UK has been bought by investment banks using futures contracts. This mixed imperfect market competition and application of financial derivatives to power trading explains partly why the banks are exposed more and more to the risk of a fall in demand for power, and partly why there is an increasing concern on a huge rise in electricity costs for the end users over recent years in the UK. Table 1 indicates that the actual cost of middle men / middle traders accounts for roughly 26 percent of the price for households, 11 percent of the price for industrial users, and households are charged 79 percent higher than industrial users.

In contrast, China takes a different structure of supply that helps avoid the cost of the middle traders, see Figure 2. China has some 80 percent of electricity from coal-fired power plants, and more than 50 percent of the coal (2.3 billion tons) produced in 2006 was consumed by power generation. There are no middle traders between the power producers and the end users. As described in Figure 2, the state regulates both transactions between power firms and a grid company and between the grid firm and the end users in terms of prices and output. The state sets a plan price ($\overline{p}$) and an annual output quota ($\overline{q}$) for each power firm to produce and trade to guarantee their basic revenues earned from the fulfilment of planned production through delivery to the grid company. The grid company has a limited degree of autonomy in choosing competitive or low-cost power firms to produce outputs above the plan when excessive demand appears. In response to excessive demand, power firms may be called to produce excessive output (n) above the basic plan. A price paid for the firm to produce excessive output can be negotiated between the producer and the local government of the end users. Often, if the excessive output of electricity needs to export to other provinces or regions where there is power shortage, the local government of the producer will act on behalf of the producer to negotiate with the local government of the end users in the other place. The sales above the basic plan are small for the firm, however, usually less than 10 percent of the total sales of the firm (Liu 2006).

In Figure 2, for simplicity, we define the negotiated price as the same as the plan price of the basic output of a power firm. As can be seen, $\overline{p}$ is an ex factory price planned by the state for each power firm to sell its electricity to the grid; $\overline{q}$ is output quantity planned by the state for each power firm; n is output produced by a power firm in excess of the planned quantity; $\overline{p}_g$ is a planned price paid by end users to the grid; and g is a price margin added by the grid on the power firm's ex factory price. $\overline{p}_i^c$ is the plan price of coal paid by a power firm to the coal producers; p_i^c is the market price of coal paid by a power firm to the coal producers to produce excessive output; $x(q)$ is the quantity of coal bought by a power firm to produce planned output. $x(\Sigma n)$ is the quantity of coal bought by a power firm to produce excessive output outside plan.

One interesting feature of Figure 2 is that the role of the middle trader is played by the grid company. The grid buys all electricity from power firms and then resells it

Table 2. China's catalogue prices of electricity for end users

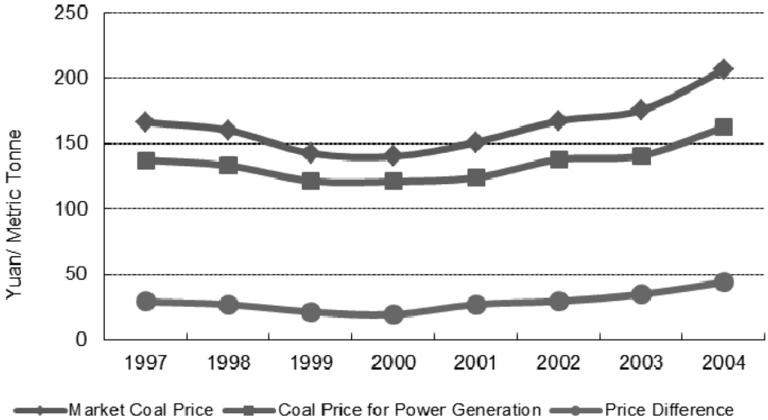
Unit: Yuan/MWh	2000	2001	2002	2003	2004
Big industrial uses[a]	372	380	NA	426	457
Common & non-industrial uses[b]	430	520	NA	583	614
Household uses[c]	379	380	NA	443	447
Lighting uses (non-household)[d]	500	590	NA	620	776
Commercial service sector uses[e]	670	690	NA	754	643
Agricultural sector uses[f]	329	330	NA	359	365
Poor counties irrigation uses[g]	146	150	NA	156	166
Sales in excess of plan[h]	328	330	NA	351	374
Average	376	396	410	435	458

Source: *Electricity Market and Electricity Prices Monitoring Report 2005.*
Note: *The catalogue (a) applies to the one, of which the capacitor exceeds 315 kV; (b) applies to the one, of which the capacitor is below 315 kV, the government departments, and the public services providers; (c) applies to the residents, kindergartens, schools, and rest homes; (d) applies to the users of the signal lamp, the street lamp, the arc lamp, and the neon light; (e) applies to the business services providers; (f) applies to those involved in the farming activities; (g) applies to the low-income counties; and (h) refers to the prices of the traded electricity in excess of plan.*

to the end users at the catalogue price set by the state. The state groups end users according to industrial/commercial users, household residential users, and low-income users. The affordability of each group is different, therefore they are charged discriminatively by the state (see Table 2). In 2006, 2,182 billion kilowatt hours (kWh) were sold to industrial/commercial users, 324 billion kWh went to household residential users, and 319 billon kWh were taken by low-income regions and agricultural users. Apparently, the price discrimination against the users according to their affordability indicates that plan prices are taken as "an instrument" partly to serve a political interest of social justice and partly to serve regional or industrial development policy. For instance, the users in low-income regions pay a price almost two times less than high-income domestic households. For the same analogy, agricultural users pay a lower price than industrial users. From 2000 to 2004, the industrial price of electricity increased by 23 percent, whereas the agricultural price only increased by 11 percent.

Figure 2 not only shows that the state fixes the prices of power sales but also that it fixes the prices of input such as coal in order to help reduce the volatile impact of input cost on the stability of the plan price. Although the coal market has been liberalized since 1993, the price of coal for electricity production (known as *electricity coal*) has still been strictly regulated by the state. The power firm pays a regulated price for coal ($\overline{p}^C$) to the coal supplier who then provides the power firm with the planned quantity of coal ($\overline{x}^C$). The planned quantity of coal only allows the power firm to produce the planned output of power ($\overline{q}$) that the firm is given by the state. For any power output above the plan, there is no guarantee of supply of the planned coal. Because the planned coal is cheaper than the market-sale coal, the coal producer has

Figure 3. Market price of coal and plan price of electricity coal in China



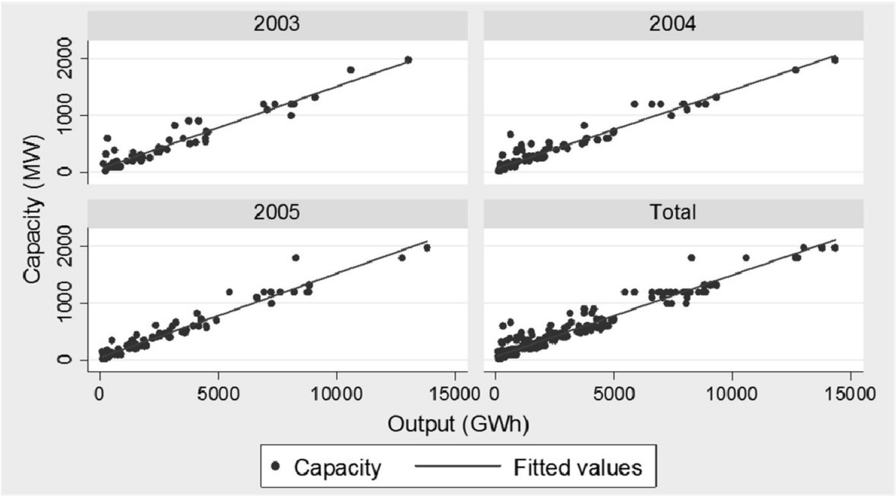
Source: *Energy Data 2005.*

no incentive to sell coal any more than the plan requires, leaving the power firm with difficulties in acquiring excessive plan coal.

It is not cheaper to produce excessive power (*n*) because the firm has to pay a market price for coal. As shown in Figure 3, the planned electricity coal is cheaper than other coal sold at a market price by 28.95 yuan/metric ton, and the gap between the plan and market prices increased up to 43.92 yuan/metric ton in 2004. This implies, first, that the planned electricity coal is underpriced significantly by the state when compared to the market. This may reflect the intention of the state to "subsidize" a plan-taking power firm with a lower coal price. Secondly, the procurement of coal from the market at a higher price can lead the firm to reduce profits by producing more output above the plan. To avoid this situation where the marginal costs are higher than marginal revenues, an alternative is to stop the excessive or non-planned production, which can create a problem of power shortage. This partly explains why power supply has been short sometimes in recent years, not because of a shortage of generating capacity, but the inability to resource cheap coal (Kroeber, Lee, and Yao 2008).

This discussion indicates that the state apparently internalizes all transactions by plan from input acquirement to output sales. In the meantime, it liberalizes both capacity investment and demand for power consumption. With this mix of a free-investment and plan-output system, the firm is given more plan output with its

Figure 4. Producer-invested capacity and state-planned output

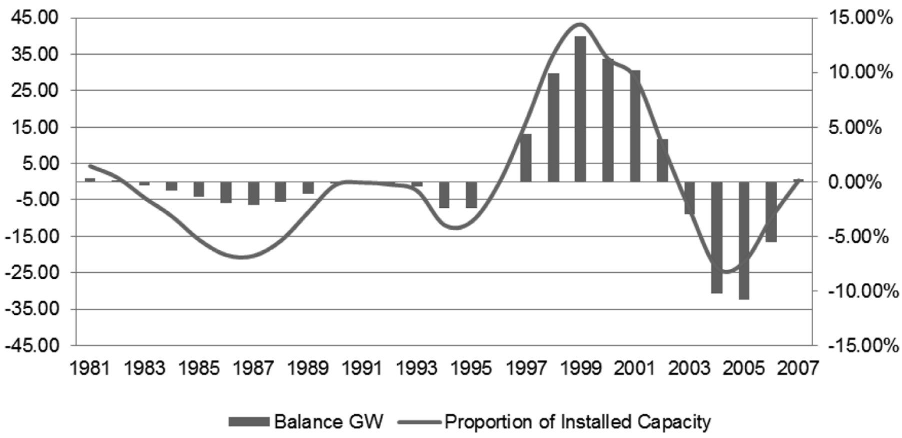


Source: *Plotted on the basis of data sources from National Bureau of Statistics of China, and China Electric Power Yearbook 2005 and 2006.*

capacity (see Figure 4). The close link of plan output with capacity stimulates the firm to invest more in capacity because this will help the firm grow and therefore earn more profits when a profit margin is included in the plan price. Due to the partial plan regulation to the coal market, it is difficult for a power firm to acquire more cheap planned coal in order to produce excessive outputs above the plan. With this difficulty, the marginal costs can be higher than the marginal revenues if the firm produces output in excess of the plan.

In short, the existing reformed plan system is different from traditional planning at least in three aspects: (1) decentralized investment decision from the state to the firm, (2) no consumption rationing imposed on demand, and (3) shifting management's accountability from plan fulfilment to profits. The first aspect means that competition can be developed for capacity expansion among power firms. The third aspect of profit accountability means that the firm is commercialized and takes the planned output target as a vehicle needed to generate sales and therefore profits that the firm seeks. The reform largely explains why the industry has built up its market-based investment mechanism to effectively respond to demand in help of avoiding a capacity shortage in the long run. Figure 5 shows a cyclical pattern of the balance of power supply in terms of its installed capacity and demand over 1981 to 2007. The figure clearly indicates a swing of supply capacity from shortage to surplus as a re-

Figure 5. The balance of installed capacity and demand



Source: The data are collected from the China Electric Power Yearbook 1980–2008, and the calculation is based on the suggestion from Arthur Kroeber (2008).

Table 3. Wholesale prices of electricity for industry: China and OECD

Price (US$/KWh)	2000	2001	2002	2003	2004	2005
China	0.0449	0.0459	0.0487	0.0515	0.0552	0.0730
UK	0.0550	0.0510	0.0520	0.0550	0.0670	0.0870
France	0.0360	0.0350	0.0370	0.0450	0.0500	0.0500
United States	0.0460	0.0500	0.0480	0.0510	0.0530	0.0570
Canada	0.0400	0.0430	0.0410	0.0490	0.0490	0.0553
Germany	0.0410	0.0440	0.0490	0.0650	0.0770	0.0840
Italy	0.0890	0.1070	0.1130	0.1470	0.1610	0.1739
Japan	0.1430	0.1270	0.1150	0.1220	0.1270	0.1227

Source: IEA, Electricity Information 2006, 36–39, and Economic and Social Data Service.

sult of firms' responsiveness of capacity expansion to demand growth from the 1990s when reform was deepened.

3. Do Chinese consumers pay less for electricity?

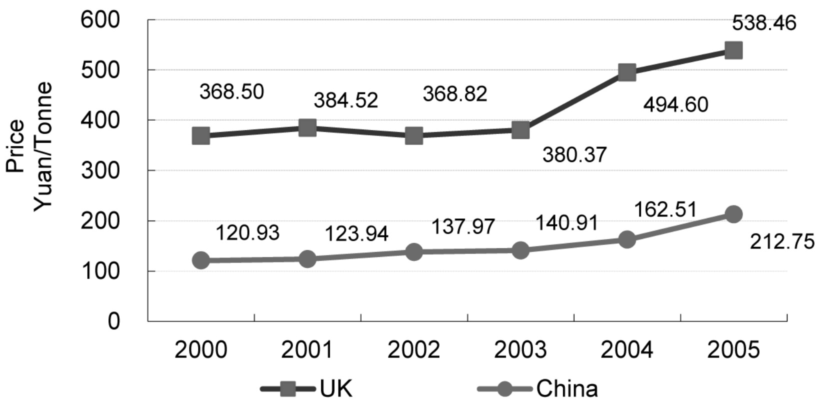
Are Chinese households better off in a regulated supply than the UK counterparts in a deregulated market? Interestingly, the answers are not definite, and depend on which criterion we refer to. For instance, from a consumer's point of view, whichever system has the lower price is the better the system. A lower price will help "consumer welfare improvement." Tables 3 and 4 show an interesting comparison of prices in terms of households and industrial users, respectively, between China's plan price and the UK/OECD market price over 2000–05.

Table 4. Electricity price for household users: China and OECD

Price (US$/KWh)	2000	2001	2002	2003	2004	2005
China	0.0458	0.0459	0.0497	0.0535	0.0540	0.0610
UK	0.1070	0.1010	0.1050	0.1160	0.1380	0.1491
France	0.1020	0.0980	0.1050	0.1270	0.1410	0.1416
United States	0.0820	0.0850	0.0850	0.0870	0.0900	0.0945
Canada	0.0530	0.0530	0.0540	0.0620	0.0676	0.0757
Germany	0.1210	0.1240	0.1360	0.1760	0.1980	0.2124
Italy	0.1350	0.1480	0.1560	0.1860	0.1910	0.1975
Japan	0.2140	0.1880	0.1740	0.1860	0.1960	0.1888

Source: *IEA, Electricity Information 2006, 36–39, and Economic and Social Data Service.*

Figure 6. Coal prices for electricity production: China and the UK

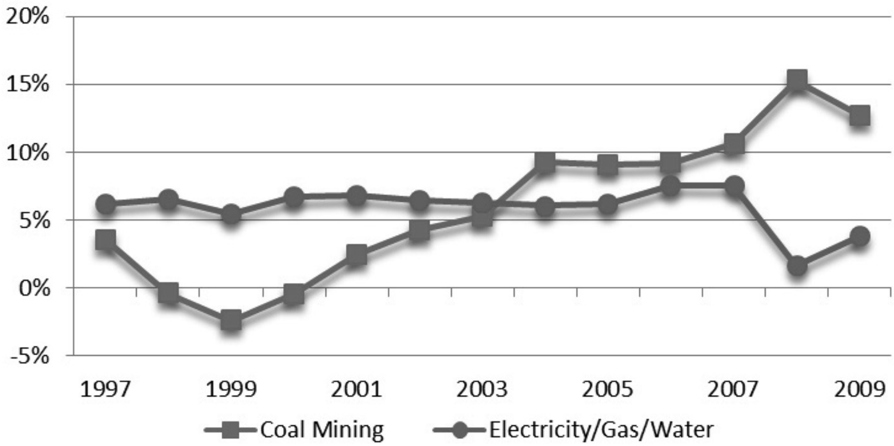


Source: *China Electricity Year Book 2005, Energy Data 2005, and IEA Electricity Information 2007.*

As can be seen in Table 3, prices are for industrial users and comparable in U.S. dollars given by the International Energy Agency (IEA), and there is not a significant difference in wholesale prices between China and OECD countries except Italy and Japan. The similarity of wholesale prices between most OECD countries suggests a price convergence to competitive equilibrium due to competition. The plan price in China is close to the OECD competitive level and implies that financially the Chinese industries do not gain any competitive advantage in acquiring cheaper power than their OECD counterparts.

Why are they similar when China has lower labor costs, a lower rate of internalization of environmental costs, a lower capital cost of construction, and lower coal prices? For instance, the price of the electricity coal has been less than 50 percent in the UK (see Figure 6). Furthermore, labor costs in China are also much lower than

Figure 7. Profit margins in China's power generation and coal mining



Source: *Kroeber, Lee, and Yao (2008).*

the OECD level; an average labor cost per worker in a profitable Chinese power firm is about RMB 40,000 a year when compared with RMB 433,000 a year at Drax, which is the UK's largest coal-fired power firm.

Moreover, due to a plan cap by the state, the profit margin of a power firm is not high, some 6 percent of the price or even lower in the two most recent years when coal prices soared (see Figure 7). This leaves only two possible explanations. One attribute is a high charge in power transmission and distribution—for instance, the two monopolistic grid corporations received total revenues of US$ 163 billion from end users and paid out US$ 98 billion to all power firms that supplied 2,834 billion kWh to the transmission in 2006. This shows that, on average, the costs of transmission charges accounted for 40 percent of the end-user price, which is higher than the UK wholesale level of 29 percent in the price (5 percent on high voltage transmission and 24 percent on low voltage distribution, see Table 1). Another possible attribute is a high level of overhead costs that may offset advantages of costs in production. This will be discussed later in the paper.

Turning to household users, if we take the wholesale price for industrial users as a baseline in measuring how high an electricity price is charged on households above the baseline, we find that the Chinese households are charged least relative to the wholesale price (see Tables 4 and 5). Again in 2005, the households were charged

Table 5. China's household price above industrial price with reference to OECD

Household Price/ Industrial Price	2000	2001	2002	2003	2004	2005
China	1.02	1.00	1.02	1.04	0.98	0.84
UK	1.93	1.98	2.03	2.12	2.07	1.71
France	2.71	2.82	2.86	2.82	2.83	2.92
United States	2.04	2.05	2.04	1.80	1.62	1.66
Canada	1.19	1.09	1.19	1.13	1.13	1.38
Germany	2.98	2.82	2.79	2.68	2.57	2.52
Italy	1.52	1.38	1.38	1.27	1.18	1.14
Japan	1.40	1.38	1.41	1.42	1.44	1.56

Source: *The OECD data of the electricity prices are collected from IEA, Electricity Information 2006; the Chinese data are collected from Electricity Market and Electricity Prices Monitoring Report 2005; the data of exchange rate are collected from DataStream.*

even less (16 percent) than the industrial users. In contrast, UK households were charged about twice the wholesale price, and France was even worse, charging almost three times higher than the wholesale price. The higher retail prices relative to the competitively formed wholesale price imply a higher transaction cost of retail in OECD countries when compared with China, in which the higher cost may come from the market power of retailers due to imperfect market competition, or it may come from higher costs incurred by them. Regardless of the sources of the cost, what we are clear about is that the closer the retail price is to the wholesale price, the lower the market transaction cost is on the small users. From this aspect of saving the market transaction cost in the retail trade, China's internalization of market transaction through plan outperforms the UK's externalization of transaction through market.

Table 5 also indicates that there is no clear evidence on significant price across subsidies from industry to households because the price ratio of the households to the industry is quite close to one—except in 2005 when the price of the industrial users rose by some 30 percent in compensation for a huge rise in coal costs. Despite a relatively lower price of electricity for Chinese households, they consume only 11.5 percent of total electricity of 2,825 billion kWh in 2006, and the rest was mostly consumed by industries and other commercial establishments. Additionally, the demand structure is quite different from OECD, for example, U.S. households consume some 45 percent of the power.

On this basis, we argue that the plan price is higher, not relative the OECD level, but relative to the potential of the cost saving that can be made by both the Chinese power firms and the grid that runs the transmission and distribution for their end users. This suggests that the Chinese industries can be powered more competitively if reform can lead the power firms to improve their cost efficiency further.

4. How is a plan price formed?

4.1 The structure of plan prices and plan supply in relation to demand

There are four prices that can decisively affect power supply and demand: coal prices that the power producers pay to coal-mining companies, on-grid prices that the grid company pays the power producers for buying their output, transmission charges that the grid marks up on using its wires and cables, and end-user prices paid by electricity consumers to the grid company. Coal prices are classified mainly according to electricity coal prices and other coal prices. The electricity coal is regarded as "a strategic product of the nation" and so is regulated by the state for its quantity and prices to ensure an adequate supply of coal at an affordable price to power firms to produce the planned output and sell it profitably at the plan price. Liberalization of the coal price has been attempted since 1992, and the latest attempt was in 2007, but the attempts were not successful as the role of the plan legacy still remains in place to mitigate the conflict of interest between the free-market supplies upstream and the plan-capped sales downstream.

On-grid prices are generally set by the price bureau of the NDRC to ensure the balance of interests between the end users and the power industry that seeks profits. The profit incentive stimulates the firm to expand capacity and also to attract new entrants. This implies that, for a given plan price, the firm shall cover its costs and also gain some surplus to invest further. As a result, electricity generators are allowed to make an 8–12 percent return on equity, based on industry average costs, so that they have the incentive to lower their costs below the average and enjoy a higher return (Kroeber, Lee, and Yao 2008). This claim is consistent with evidence of both the 6 percent profit margin in the regulated on-grid price, and the finding of a good price mark-up in the price reported by Wang (2006).

Regarding costs embedded in the on-grid price, there are two different types, one at a regional level and another at a firm level. The prices differ with regions. The NDRC sets its regional prices according to, first, the regional stages of economic development that reflects different living costs and affordability, and secondly, the transportation cost of coal.

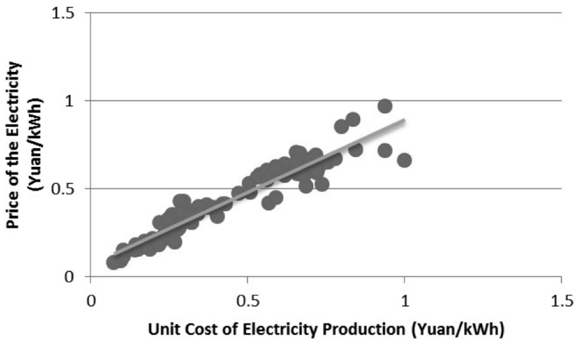
Having set a regional on-grid price by the state as a general guidance for an area or a province, the NDRC allows a further adjustment of the general guidance made by its local offices or local NDRCs to a firm-level plan price that an individual power firm can sell at. In reality, it is difficult to impose a unified adjustment for different power firms because their cost conditions and historical context of business are different. The local NDRC has to be involved in assessing firms' cost conditions individually to set up an individual adjustment, resulting in one firm with one adjusted plan price. This creates an institutional opportunity for power firms to influence the state via "lobbying for an on-grid tariff high enough to cover their fuel costs and ensure that they will be profitable enough to make the necessary investments" (Rosen and Houser 2007, 25). The cost adjustment of the general guidance price is further documented by the Electricity Annals of China (2006) in which the state stipulates a computational method about how to adjust the general price with the cost and other conditions of the firm such as market conditions, the firm's own finance costs, an intensity of depreciation, fuel costs and other variable costs, and the capacity utilization rate.

Furthermore, the state also allows a price adjustment to compensate a rise in input costs, such as coal prices. The price compensation of the cost pass through is not full, depending on a number of factors, such as a percentage of a rise in coal price that the firm can bear or internally digest, the technical efficiency of power generators used in turning coal to electricity, and the quality of coal used by the firm. For example, from 2001 to 2003, the coal price in China increased by around 13.7 percent, bringing on-grid prices up by 9.8 percent on average.

This discussion highlights that, first, the cost is a key element that determines the adjustment of the general plan price for an individual firm. Figure 8 clearly demonstrates this point that the higher costs are associated with higher prices—a typical pattern of the soft price constraint on costs. Second, the adjustment has to be individually made because the cost conditions cannot be identical for every firm. As a result, it is expected that the firm will use its cost information to influence or negotiate with its local NDRC for a favorable adjustment and therefore receive a higher plan price. This clearly suggests that negotiation or bargain is inevitable in the process of the price setting.

The institutional formation of on-grid prices complicates price equilibrium between power producers as a seller and the grid corporation as the only buyer who is given planned grid prices to purchase power from the power firms. The grid company resells the power to end users at an end-user tariff or a catalogue price that covers the on-grid prices, transmission charges, further surcharges on grid investment of US$ 130 billion between 2006 and 2010 (Rosen and Houser 2007), and some policy adjustments for different end users. The NDRC sets prices for the end users in a region in consultation with local governments in an attempt to balance the interests of various parties. Demand responds directly to the end-user price, but not to the on-gird prices that are responded by suppliers. Figure 9 shows how these two prices were related to the capacity of power firm, respectively, in 2004. Obviously, the

Figure 8. On-grid price and the unit cost of power producers



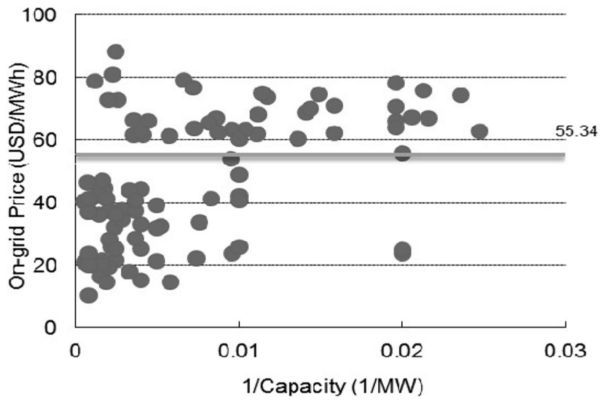
Source: *National Bureau of Statistics of China and Electricity Annals of China (2004, 2005).*

figure shows that the large firms are given lower on-grid prices, but the end users are given a flat price regardless of the capacity.

In Figure 10, $\overline{p}$ represents the planned price set by the state for the end users, which crosses the demand curve D_1 at the point O. The market demand in response to $\overline{p}$ is q. The difference between q and K measures capacity surplus because K represents the maximum of total aggregate capacity available in the nation at the time. If $q > K$, there is a capacity shortage. To supply q, the aggregate capacity of n firms is chosen, and the n firms are ranked according to their marginal costs that will lead the state to determine their on-grid prices respectively in selling their power. The line that ranks the marginal cost of each power firm is the supply curve. The vertical length of each level (or a step) on the ladder line (the supply curve) represents an on-grid price of the firm, and the horizontal length between the lower step and the higher step is the capacity of the firm. The monopolistic grid firm purchases power up to q from the power firms at given plan prices ranged from the highest $\overline{p}^H$ to the lowest $\overline{p}^L$, and then the grid resells q at a single price of $\overline{p}$. The income of the grid firm is the sum of gains and losses, where gains are from paying on-grid prices that are lower than the end-user price, indicated by the area below the price line $\overline{p}$ and above the supply curve S (see Π_1 in the figure). In contrast, the losses are from paying the on-grid prices higher than the end-user price, which is the area of Π_2 that is below the supply curve and above the price line $\overline{p}$.

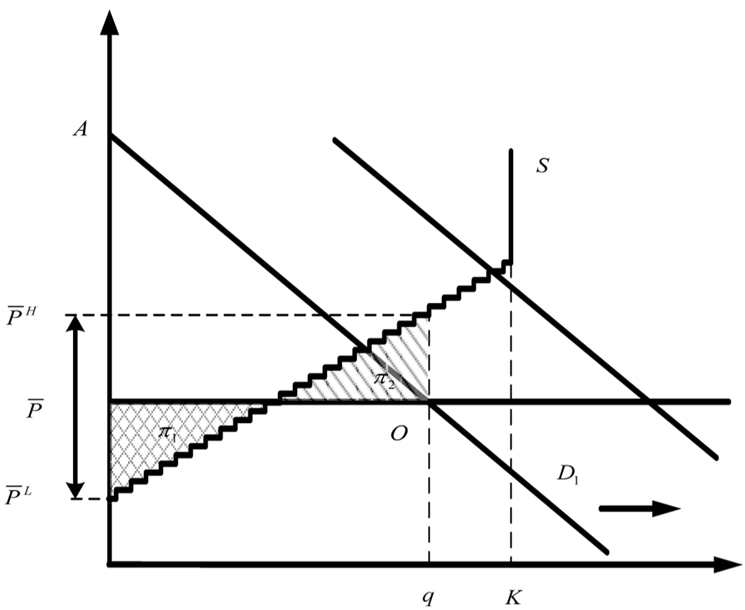
Clearly, the diagram shows that the loss of social welfare is not a result of market power but of the inefficient supply of the high cost firms, indicated by Π_2. If the line of the end-user price holds, the shaded loss area of Π_2 can be reduced by shifting the

Figure 9. Observation of capacity, market demand, and plan supply



Source: *National Statistics Bureau of China.*
Note: *The solid flat line represents the average price of the end users in 2004, and the dots represent the on-grid price of each power firm for the corresponding year.*

Figure 10. Equilibrium structure on-grid prices, and the end-user price



Note: *$\overline{P}^H$ = the highest on-grid price ; $\overline{P}^L$ = the lowest on-grid price; $\overline{P}$ = the average price of end users; π_1 = profit gain of the grid; π_2 = the losses of the grid; D = the demand curve; S = the supply curve; q = the actual output of the electricity produced; K = the maximal capacity that all of power firms can produce; y axis = the price of the electricity; x axis = the production of the electricity.*

supply curve right: either by reducing the on-grid prices of power producers or by allowing the efficient firms to expand and inefficient ones to shrink. The price reduction creates a conflict of interest for the power firms, because they prefer higher prices to better cover their costs. The high-cost firms can also be protected by the higher price due to the soft price contraint. In short, Figure 10 demonstrates how plan supply, market demand, and plan prices interact with each other in the Chinese electricity market.

Empirically, Figure 10 can be illustrated by using the sample of the data of 110 power firms located in the southern provinces of China. We plot the on-grid prices of power firms in the South versus their output (the average end-user price in the south was US$ 55.31 MWh in 2004, see Figure 9). As expected, of 110 power firms, there were 59 firms that sold their power to the grid at sale prices below the end-user price, allowing the grid to earn income of US$ 4,523 million (equivalent to area Π_1 in Figure 10), when compared with the rest of high-costs-with-high-price firms that made the grid lose US$ 473 million in 2004 (equivalent to area Π_2 in Figure 10). The power firms that brought losses to the grid are small, with an average annual output of 6,369 MWh, when compared with the size of an average output of 29,872 MWh of the low-cost firms. This indicates that the size of power firms matters not only for cost efficiency but also for the profitability of the grid firm.

4.2 The model of price bargaining between the state and the power firms

One phenomenon of the on-grid prices is the soft price constraint on cost: the price of each firm is planned by the state individually in line with its own cost. This implies that the firm could negotiate with, or influence, the state in setting its plan price. To model this negotiation process, we start by assuming that the state planner sets a price to maximize the total output of the whole industry (Q) of the nation for given resources available at time t. This price is denoted as $\bar{p}_t$, called an aggregate plan price for power producers to sell their electricity.

In a symmetric scenario, every power firm has an identical cost. If this is the case, then the planner can set a plan price of each individual firm i to equal the aggregate social plan price at $\bar{p}_{it} = \bar{p}_t$.

In fact, firms are different and so are costs. Thus the aggregate plan price will be adjusted by the planner to account for an individual firm's productive condition and cost, making one firm with one plan price reflect different cost conditions of power firms. The adjustment of a plan price for a firm's cost at c_{it} can be described as follows:

$$\frac{\bar{p}_{it}}{c_{it}} = \left[\frac{\bar{p}_t}{c_{it}}\right]^{\lambda}$$

$$\text{or } \bar{p}_{it} = [\bar{p}_t]^{\lambda}\, C_{it}^{1-\lambda}\ , \tag{1}$$

where λ is a cost adjustment coefficient for a plan price at a range between 0 and 1. If $\lambda = 0$, it means that the aggregate plan price is fully adjusted to equal the cost of an individual firm. If $\lambda = 1$, it means that the aggregate plan price is not adjusted at all and it remains the same. So λ indicates how far the aggregate plan price is adjusted to account the cost of the firm. In other words, the more the adjustment the higher the price of the firm will be because the more cost impacts are taken into account in setting a plan price.

Furthermore, in equation (1), the aggregate plan price $\bar{p}_t$ can be transformed more specifically by specifying the total output of the industry Q as a sum of the planned aggregate electricity output, q, and the output of other industries using electricity to produce goods, Q_j, which is

$$Q = q + Q_j\ . \tag{2}$$

Because the state attempts to set the aggregate plan supply of electricity (q) as much as possible to meet the output growth of other industries that demand for electricity as a basic input for their production, it links q with Q_j as $q = q(Q_j)$ that has the property of $dq/dQ_j > 0$. The plan supply responds not only to the aggregate demand both in the short run and in the long run, but also to a planned price. The planned price can serve as an incentive to influence the decision of a power firm in choosing its capacity of supply in the long run. Due to the firm being given autonomy to choose its capacity, the higher planned price can induce the firm to invest more in capacity. This will enable the state to have more capacity for planning more output q, so that this gives $q = q[Q_j(p),\bar{p}]$ with the property of $\partial q/\partial \bar{p} > 0$. $Q_j(p)$ states that other industries are operated in a free market and so their output is a function of a market price p with $\partial Q_j/\partial p<0$. On this basis, we write equation (2) as

$$Q = q[Q_j(p), \bar{p}] + Q_j(p)\ . \tag{3}$$

If we consider an argument that the aggregate plan supply of electricity can also serve as "a strategic constraint" on the output of other industries, in which this has been a particular case where the shortage of power is common in an economy, then equation (3) can be augmented as

$$Q = q[Q_j(p), \bar{p}] + Q_j[p, q(\bar{p})]\ . \tag{4}$$

With account of the impact of electric power costs or the plan price ($\bar{p}$) on the market price of other products (p), we maximize the total output of both electricity and other industries, Q, which is the objective of the state planner in choosing a plan price, and gives the following:

$$\frac{dQ}{d\bar{p}} = \frac{\partial q}{\partial Q_j}\frac{dQ_j}{dp}\frac{dp}{d\bar{p}} + \frac{\partial q}{\partial \bar{p}} + \frac{\partial Q_j}{\partial p}\frac{dp}{d\bar{p}} + \frac{\partial Q_j}{\partial q}\frac{dq}{d\bar{p}} = 0\,.$$

Manipulating the above results in

$$\left[\frac{\partial q}{\partial \bar{p}}\frac{\bar{p}}{q}\right]\frac{q}{\bar{p}} = -\frac{\partial q}{\partial Q_j}\frac{dQ_j}{dp}\frac{dp}{d\bar{p}} - \frac{\partial Q_j}{\partial p}\frac{dp}{d\bar{p}} - \frac{\partial Q_j}{\partial q}\frac{dq}{d\bar{p}}\,.$$

Then the aggregate plan price becomes:

$$\bar{p} = \frac{\varepsilon}{\sigma}q \tag{5.1}$$

$$\text{where } \varepsilon = \frac{\partial q}{\partial \bar{p}}\frac{\bar{p}}{q} > 0 \text{ and } \sigma = \rho - \frac{\partial Q_j}{\partial q}\frac{dq}{d\bar{p}} \text{ and } \rho = -\left[\frac{\partial Q_j}{\partial p}\frac{dp}{d\bar{p}} + \frac{\partial q}{\partial Q_j}\frac{dQ_j}{dp}\frac{dp}{d\bar{p}}\right], \tag{5.2}$$

where ε is the price-incentive elasticity of output to reflect how a commercialized profit-making firm will respond to plan prices in choosing its capacity. The state plans output for a firm according to its capacity, and the elasticity is expected to be positive since the higher plan price will induce more capacity expansion and, therefore, output. This suggests that ε>0 due to $\frac{dq}{d\bar{P}}$.

For σ, it is expected to be negative. This is, first, ρ ≤ 0, or at least, in the short run. A change in electricity prices ($\bar{p}$) will not be immediately responded to by a change in the product price of other industries (p) because (1) product competition can enforce the firm to internally absorb a cost rise as much as possible and (2) the price adjustment made by the firm in response to costs will be lagged. This shows $\frac{dq}{d\bar{P}} = 0$ in equation (5.2). As a result, we expect ρ ≤ 0.

Secondly, the marginal output of other industries with respect to supply of electricity is positive, $\frac{\partial Q_j}{\partial q} > 0$. This ensures $\frac{\partial Q_j}{\partial q}\frac{dq}{d\bar{p}} > 0$, so that with ρ ≤ 0 we expect σ<0 in equation (5.2).

This discussion shows the expectation of the negative relationship between the electricity price and the aggregate power quantity supplied. The negative relationship of the supply in relation to the plan price implies that industrial or economic growth will be very much affected or constrained by power supply. This creates a strategic incentive for the state to plan not only more quantity needed to be supplied but also plan that quantity at a lower cost to stimulate demand for power in order to produce more, and in that way grow the economy. This explains why the electricity price and quantity supplied is regulated in China because of the growth pursued by the state.

To substitute equation (5.2) for $\bar{p}(Q)$ in equation (1) gives us

$$\bar{p}_{it} = \left[\frac{\varepsilon}{\sigma} q_t\right]^{\lambda} C_{it}^{1-\lambda} \,. \tag{6.1}$$

Or, in a non-linear form, the equation can be presented as

$$\bar{p}_{it} = q_q^{\lambda\gamma(\varepsilon,\sigma)} C_{it}^{1-\lambda} \,, \tag{6.2}$$

where γ is a coefficient affected by ε and σ, and its empirical sign indicates a technological impact on the other industry in using electricity. The impact will affect the state planner in setting up its plan price in relation to supply: $\gamma < 0$ means that the high-electricity-intensity technology is dominant in the production of the other industries, and therefore the industries are less capable for sustaining the high costs of power supply. For sustainability, the state is expected to plan more power supply but at a lower cost in order to stimulate output, and thus economic growth. In contrast, if $\gamma > 0$ empirically, it means that the low-electricity-intensity technology is dominantly adopted by the other industries, and therefore the industries can be more capable for sustaining the high costs of power supply, in which the state can leave the power industry to decide how the price shall be set in relation to required supply.

To turn to the impact of costs on the plan price in equation (6.2), it is expected that the effect of an individual firm's costs on setting a plan price will lead to one firm with one plan price. In response to this institutional arrangement, the firm will be motivated to play a high-cost strategy. The high-cost strategy can allow the firm to bargain with the state planner for a higher plan price in order to offset the firm's higher costs. Therefore, the cost will be expected as a central factor affecting the plan price of a firm in the Chinese power industry.

To test this expectation, we can further break down the cost factor, *C*, in equation (6.2) into different cost elements that the firm could take to bargain with or affect the state planner for a higher price.

$$\bar{p}_{it} = q_1^{\lambda\gamma(e,\sigma)} c_{jt}^{\eta(1-\lambda)} r_{it}^{\beta(1-\lambda)} m_{it}^{\phi(1-\lambda)} c_{it-1}^{\theta(1-\lambda)} D_t^{\omega}\,, \tag{7}$$

where, first, *r* is the cost of capital. The firm can strategically raise the cost of finance or capital, such as take more bank loans to finance its projects, set up a higher depreciation rate, and so forth, in bargaining a higher price to offset part of the finance costs. The second is a fuel price or raw material price denoted by *m* in equation (7), which shows that the firm could ask the planner to pass their costs through due to a higher input costs. The third is the overall average unit cost in the previous period, denoted by c_{it-1} in equation (7), in which the past cost could be used as a starting point for the price bargain between the state and the firm. We also consider the profitability state of the firm that can affect its bargain with the state. It is also possible that the firm could use the cost of rival firms (c_j) as an indication of the cost environment for the firm to bargain for a higher price. If the price serves partly as an income distribution among power firms, then a soft price constraint will be expected to help the loss-making firm receive a higher plan price than the profit-making firm. In equation (7), *D* denotes the profitability state of 1 for profits and 0 for losses.

We take the logarithm of equation (7) with further inclusion of a market share variable (*s*), the average rival cost (c_j), and other two dummy variables of location (D^L) and affiliation (D^A) in our econometric model of the plan price bargaining:

$$\begin{aligned}\ln \bar{p}_{it} = \alpha + \hat{\gamma}\ln q_{it} + \tau\ln s_{it} + \hat{\eta}\ln c_{jt} + \hat{\beta}\ln r_{it} + \hat{\phi}\ln m_{it} + \hat{\theta}\ln c_{it-1} + \omega d_t \\ + \xi d_t^L + \kappa d_t^A + \mu_{it}\,,\end{aligned} \tag{8}$$

where μ is disturbance term with normal distribution, $\hat{\gamma} = \lambda\gamma$, $\hat{\beta} = \beta(1-\lambda)$, and $\hat{\eta} = \eta(1-\lambda)$, $\hat{\phi} = \phi(1-\lambda)$, $\hat{\theta} = \theta(1-\lambda)$.

To pursue the robustness test, we break the cost of capital (*r*) according to interest rate (*i_r*) and depreciation rate (*d_r*):

$$\begin{aligned}\ln \bar{p}_{it} = \alpha + \hat{\gamma}\ln q_{it} + \tau\ln s_{it} + \hat{\eta}\ln c_{jt} + \hat{\beta}_1\ln i\_r_{it} + \hat{\beta}_2\ln d\_r_{it} + \hat{\phi}\ln m_{it} \\ + \hat{\theta}\ln c_{it-1} + \omega d_t + \xi d_t^L + \kappa d_t^A + \mu\,.\end{aligned} \tag{9}$$

Moreover, we also test the price-cost margin (p^M) impact of the bargaining factors:

$$\begin{aligned}\ln \bar{p}_{it}^M = \alpha + \hat{\gamma}\ln q_{it} + \tau\ln s_{it} + \hat{\eta}\ln c_{jt} + \hat{\beta}\ln r_{it} + \hat{\phi}\ln m_{it} + \tau\ln LF_{it} \\ + \omega d_t + \xi d_t^L + \kappa d_t^A + \rho_{it}\,,\end{aligned} \tag{10}$$

$$\ln \bar{p}_{it}^{M} = \alpha + \hat{\gamma}\ln q_{it} + \tau\ln s_{it} + \hat{\eta}\ln c_{jt} + \hat{\beta}_1\ln i\_r_{it} + \hat{\beta}_2\ln d\_r_{it} + \hat{\phi}\ln m_{it} + \tau\ln LF_{it} + \omega d_t + \xi d_t^L + \kappa d_t^A + \rho_{it}\,, \tag{11}$$

where we add the load factor (*LF;* this represents actual output over the expected maximal output in the full capacity) in equations (10) and (11) to further test if there is a soft price constraint effect on the profit margin in the plan price, since the state planner could set up a high profit-margin price for a firm with a lower load factor in order to provide the firm with a favorable price as a budget support to subsidies or compensate the firm that has a lower capacity utilization.

5. Estimation of the pricing model

5.1 Data description

Data from two sources were used to test models (8), (9), (10), and (11). One is the financial and accounting data of all individual power firms during the period from 1999 to 2005, prepared by the State Bureau of Statistics of China. Another is from the Electricity Annals of China (2005, 2006) that published the generated volume and installed capacity in kWh per year for each of the 110 power firms located in the five southern provinces in China in 2003, 2004, and 2005. The combination of the two data sets provides a 3-year short panel as a sample for testing the pricing behavior of Chinese coal-fired power firms. The variables used in estimation of the models are defined as follows.

Price ($\bar{p}_{it}$): On-grid prices are an annual-based ex factory plan price fixed by the state through negotiation with the firm. Once the price is agreed, then the firm can settle its sales revenues with the grid company according to the firm's volume taken by the grid over a year. This allows us to use an annual-based on-grid price as the dependent variable for models (8) and (9), which is calculated from the annual sales revenues of electricity of the firm divided by its volume sold per year. Our construction of the price is different from Lam (2004): in this paper, it is the plan price of the firm to sell its produced power to the grid company; Lam used a regional price of the end users for his study.

The paper also tests the profit margin of the plan price for models (10) and (11), and the price margin is calculated using the sales revenue divided by the total costs of the firm.

The regional output of electricity (q) and market share (s): Because the Electricity Annals list all of power firms located in the South that sell the power to the Southern State Grid Corporation, we then can calculate the total output of the region by summing their outputs sold to the regional monopolist grid. Once we have the total output of the region, then it is easy to derive a firm's market share by dividing an individual firm's output by the regional total. Each firm's annual volume produced is reported in the Electricity Annals of China (2004, 2005, 2006).

The unit cost (*c*): The unit cost variable is the sum of the costs of sale (covering all variable costs, wages, and depreciation) plus overhead, in which the sum is divided by the annual volume of power bought by the grid. To capture the effect of the cost environment on price bargain, we use the variable of the average unit cost of the rival firms.[2] Furthermore, we also take the lagged unit cost of the firm to test the effect of the past cost information on the bargain. One advantage of using the lagged unit cost variable and the rival cost variable is to help avoid a potentially direct endogenous problem in our short-panel estimation.

The cost of capital (*r*): The cost of capital variable consists of two components. One is an interest rate that is calculated using reported account information on the annual finance costs (mainly interest payments) and the total of outstanding interest loans. The second is the depreciation rate calculated from the firm's report on the annual cost of depreciation and the book value of fixed assets. The sum of these two elements gives the cost of capital for our model tests. We also place interest and depreciation separately in regression for the robustness tests to see which component will have a more significant role in influencing the price bargain.

Fuel inflation (*m*): The fuel-inflationary variable is measured by the ratio of the coal cost per unit of electricity generated at year t to the same unit cost at year $t-1$. The ratio reflects a change in the unit of costs, indicating the inflation on the cost of coal if the technological efficiency remains unchanged over a year. The cost of coal is from the reported annual cost of sales minus both total wage costs and depreciation charges, which gives the residual as a proxy of the costs of material inputs that consist of mainly coal consumed by coal-fired power firms.

Load factor (*LF*): The load factor, known as the capacity utilization rate, is the ratio between the actual output generated by a power plant and the output that the plant would have produced at its full installed capacity at time t. It is an indicator of the capacity utilization of the power firm.

2 This is defined as $c_{jt} = [\sum_{k=1}^{n} c_{kt} - c_{it}] \;/\; (n-1)$, where n is the total number of sample firms in time t, c_{it} is the unit cost of the individual firm i in the time t with $k \neq i$. The rival cost variable reflects those rival firms in the same region but excluding the one i.

5.2 Estimation and interpretation

Pricing models (8), (9), (10), and (11) are estimated using the panel data fixed-effect estimation to run regressions against a panel sample of 110 firms over three years: 2003, 2004, and 2005. After dropping those lagged observations and extremes, there are only two years of observations that are valid to run fixed-effect-panel regressions. Our estimated results are given in Table 6.

Overall, the price bargaining model is estimated rigorously across different specifications including both models that have the price and price margin as a dependent variable, respectively, to have a robustness test on the consistency of estimations. The estimation of the model is statistically consistent with our theoretical expectations. Although the panel sample is flat in terms of time horizon, the firm-specific fixed effects are controlled by having firm dummies in all of the regressions.

Interestingly, the state of profitability as an indicator reflecting the financial condition of the firm is negatively related to both the price and the price margin, in which the significance of the profitability dummy appears across all four estimations. This finding suggests that the state sets a lower plan price for the profitable firms and a higher plan price for the less profitable firms. Clearly this indicates that the price is used as an instrument to help subsidize the loss-making firms by authorizing them to charge more. The evidence of the soft price constraint on costs can be further shown by the sign of the load factor variable in determining the price margin: The higher price margin is set up by the state to the firms with a lower utilization of their capacity. Capacity utilization increasing with firm size was evident in Lopez (2006) in the study of UK coal-fired power firms, the larger the firm, the higher the utilization rate will be. This view is echoed by Chinese counterparts (see Tables 6 and 7). The link between capacity utilization and capacity size is because the large firms with the economic scale attract demand (Stewart 1979; Bateson and Swan 1989) and therefore stimulate a higher utilization. As shown in Tables 6 and 7, the negative relationship between the load factor and price margin implies that the state protects the weak firms by allowing them to sell at a higher plan price to compensate their high cost. Table 7 further illustrates the evidence in support of our interpretation of the estimates—the effect of a soft price constraint on costs.

As explained by our price bargaining model, the sign of the coefficient of the aggregate output (q) reflects the importance of electricity to economic growth. The negative sign of the variable and the high marginal output of the power supply indicate that the Chinese economic growth is highly responsive to power supply. This interpretation is further reflected by the close link of electricity output with GDP over time in China; this link is in sharp contrast to the UK's wedge-like relationship—

Table 6. The determinants of the electricity prices of the coal-fired power producers in China—Estimation of pricing models (8), (9), (10), and (11)

	Model 8 **Log price**		**Model 9** **Log price**		**Model 10** **Log price-cost margin**		**Model 11** **Log price-cost margin**	
Independent variable	**Coefficient**	***t*-statistic**	**Coefficient**	***t*-statistic**	**Coefficient**	***t*-statistic**	**Coefficient**	***t*-statistic**
Constant	2.427	1.8	1.989	1.4	**2.820*****	**3.7**	**2.837****	**3.2**
Total output of the region (Log Q_{t-1})	−0.321	−1.9	−0.059	−1.3	**−0.335*****	**−3.4**	**−0.335****	**−3.0**
Average cost of rival producers (Log c_{jt})	**0.628*****	**4.4**	**0.415***	**2.4**				
Average cost of rivals [Log (c_{jt}/c_{it-1})]					**0.100**	**1.9**	0.106	1.6
Market share of the firm (Log s_{it-1})	0.026	0.8	−0.007	−0.3	**0.032**	**1.9**	**0.038**	**1.9**
Lagged cost of the firm (Log c_{it-1})	**0.222*****	**3.6**	**0.155***	**2.1**				
Cost of capital (Log r_{it})	**0.049****	**3.0**			−0.016	−1.3		
Interest rate (Log i_r_{it})			**0.033****	**2.7**			−0.002	−0.2
Depreciation rate (Log d_r_{it})			0.024	1.1			−0.010	−0.5
Price inflation of coal (Log m_{it})	**0.277*****	**6.7**	**0.192*****	**4.0**	**−0.100****	**−2.7**	**−0.110****	**−2.4**
Load factor (Log Lf_{it-1})					**−0.124****	**−3.2**	**−0.133****	**−2.9**
Profitability of the power firm (1 for profit, 0 for loss)	**−0.127*****	**−4.0**	**−0.073***	**−2.1**	**−0.065***	**−2.2**	**−0.059**	**−1.8**
Location of the power firm (1 in Guangdong, 0 in others)			**0.229***	**2.5**	**−0.152**	**21.9**	**−0.147**	**−1.7**
Affiliation of the power firm (1 with central, 0 with local)	**−0.309****	**−2.6**	−0.178	−1.5	**−0.190**	**−1.9**	−0.181	−1.6
R^2 (adjusted)	0.98		0.95		0.662		0.612	
Standard error of estimation	0.118		0.110		0.098		0.105	
Number of observations	191		180		191		180	
Number of plants	99		96		99		96	
Hausman test on firm effect $(\chi^2)^a$	12.59		32.59		34.42		33.73	

Source: *The data are obtained from the National Statistics Bureau of China, and the results are generated by the authors' calculation.*

Note: *a. H0: difference in coefficients not systematic.*

Dependent variable: Log price in Model 8 and Model 9; log price-cost margin in Model 10 and Model 11.

t-statistics in parentheses.

Statistically significant at the 5 percent level. **Statistically significant at the 1 percent level. * Statistically significant at the 0.1 percent level.*

Table 7. Major business characteristics of power firms: Smallest vs. Largest

	2004		2005	
	10 smallest firms	**10 largest firms**	**10 smallest firms**	**10 largest firms**
Average capacity (10 MW)	6.09	120.45	4.63	132.49
Average output (10^5 MWh)	2.56	77.05	2.09	80.08
Average load factor (%)	56.9	72.3	56.9	68.0
Average price (yuan/KWh)	0.459	0.331	0.539	0.340
Average unit cost (yuan/KWh)	0.471	0.256	0.563	0.274
Average operational profit (yuan/KWh)	(0.012)	0.075	(0.024)	0.066

Source: *China Electricity Year Book 2005, China Electricity Year Book 2006.*

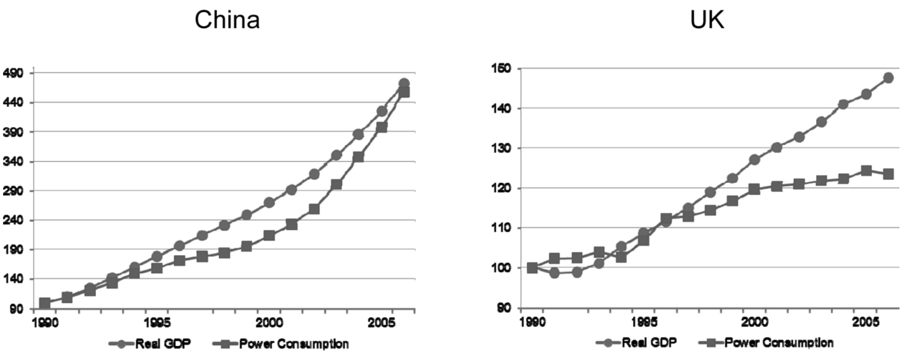
almost unlinking the two. The reliance of China's economic growth on power is obvious,[3] because its half of GDP come from manufacturing, and for the UK it was only 27 percent in 2007. This creates a growth-driven incentive or pressure on the state to seek more power supplied at a cheaper cost.

The growth-driven effect on the price is subject to the cost constraint that can affect the sustainable development of the power industry, however. Estimation of the cost impact on prices in Table 6 clearly sheds light on this argument. For instance, all of the cost-related variables, such as the business condition of costs measured by the cost of rival firms (c_j), the lagged cost effect of the firm on price adjustment (c_{t-1}), and the fuel cost inflation (m), are significantly positive related to the price. If we add the estimated coefficients of these three cost variables together minus the coefficient of the price impact of the demand, we find that the net cost impact is about 0.756 ($0.415 + 0.155 + 0.195 - 0.039$) in the first column of Table 6, and 0.806 ($0.628 + 0.212 + 0.277 - 0.321$) in the second column. The net cost impact means that on average the state allows an increase in the price by 0.8 percent in response to a 1 percent increase in the total costs after taking into account a demand pressure on lowering the price of supply. The finding implies that, first, the cost is the king in the price bargain, and secondly, a plan price is an outcome of the balance of interests between various parties.

The balance of interests can be further shown by two estimations that represent two opposite interests in affecting the price. One is about the cost pass-through. Table 6 shows that the firm has only roughly 20–28 percent of the rise in the coal cost passed through to the price. The estimated 20 percent is the pure effect of changing coal costs on the price, when others remain unchanged. The 20 percent of the cost pass-though from the power firms to the end users through the monopolist grid com-

3 Our regression of the Chinese GDP growth on the growth of its aggregate supply of power over the period from 1970 to 2007 finds some 0.7 percent growth of GDP in response to 1 percent extra growth of electricity. The UK results are insignificant.

Figure 11. The real GDP index and the power consumption index of China and the UK (1990–2006)



Source: *UNdata, International Energy Agency, and the National Bureau of Statistics of China.*

pany led the end-user price to increase by some 20 percent in response to the rise in the coal price in 2004 (Rosen and Houser 2007). In contrast to 40 percent of the high cost pass-through in 1998 when the coal price was low, the recent lower cost pass-through of the coal costs is due to the situation where the coal price has surged rapidly since 2004 (see Figure 11). In response to this dramatic volatile situation in the upstream energy market, the state has become tougher in tightening its control on the cost pass-through to stabilize the prices in the downstream sectors. Therefore, the power firms are taken as "the price stabilizer" to play a key role in absorbing the economic impact of the price volatility in the coal market that provides more than 70 percent of fuels of the nation for electric power generation.

To sustain the electricity industry, the power firms need a price that covers their costs. With this expectation, the firm is likely to be motivated to pursue a high-cost strategy to strengthen its bargain for a high price. The high-cost strategy provides the firm with two advantages. First, it can help the firm raise more financing from both internal and external sources, such as setting a high depreciation rate to raise more cash through saving the corporate tax costs, or taking a high interest rate to help borrow more. Secondly, the high-cost strategy can help the firm transfer its additional costs, particularly, the overhead costs, or any costs in relation to the rent-seeking or equivalent, to the final consumers through the price because of the soft price constraint—the high cost is covered by the high price. So it is not surprising to identify a positive link of the cost of finance with the price (see Table 6). This implies that the firm gains more finance at the expense of the public that pays the high price to cover the high costs of finance. Apparently, due to lack of competitive pressure on the firm to set its costs, the balance of interests in the price bargain is hard to keep without a bias toward the corporate favors, and then the plan price has to be set in accommodating the price failure in acting as a hard constraint on costs, leading the firm to benefit from its high-cost strategy.

6. Conclusions

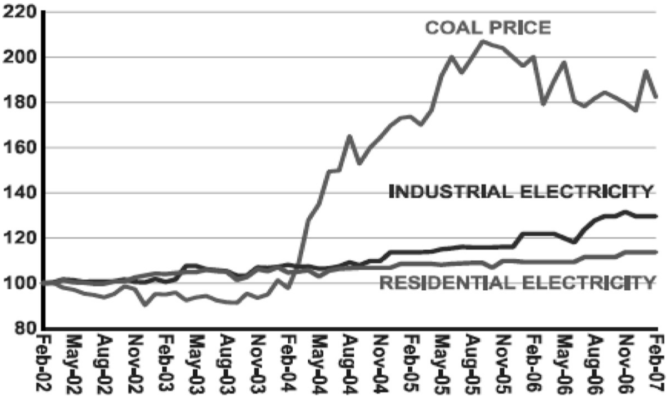
After three decades of market-oriented reform, China's electricity sector is still regulated by the state plan. There are four parties involved in the plan: the coal producers, the power producers, the power distributor, and the power consumers. Each party is linked by three plan prices: the plan price for the sale of the electricity coal to power producers, the plan price for the sale of electric power to the distributor, and the plan price for the distributor to resell the power to the end users.

The coal producers have no incentive to supply electricity coal because the price of the electricity coal is lower than the market value. The power firms cannot offer the market price of coal to produce more power in excess of the planned output because of two constraints: the plan price for selling power is too low to cover the cost of coal at the market price, and the plan supply of the cheaper electricity coal is limited (Figure 12). Therefore, the coexistence of surplus in generation capacity and the shortage of power supply in the economy often happens.

We find that the plan price is a negotiated outcome that takes into account the interests of various parties. The bargaining mechanism compromises the public interest by instituting a soft price constraint on the costs of the firm. This explains why the price of electricity in China is similar to the price in the OECD even though China has lower cost in investment, coal, labor, and environmental protection. This cost inefficiency could even offset the advantages of the current "new reformed plan" system in stimulating the rapid expansion of power generation capacity.

How should the current plan supply be reformed further to address the problem of cost inefficiency? Should China undertake full liberalization from the coal price to the end-user price like in the UK? In our opinion, the growth of the Chinese economy relies more on the use of electric power than the UK. The economic growth is essential for job creation. The growth concern explains why the government intends to retain the price control to the power supply. Price control deters further reform of the current "new reform plan." It impedes the resolution of two critical challenges: improving cost efficiency and increasing effective supply, in particular, increasing the supply of electricity coal to the power producers at an affordable price.

Figure 12. China's average index of coal and electricity price



Source: *Rosen and Houser (2007) and China Statistical Yearbook.*

Note: *Export coal price is used as proxy for the spot market price.*

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