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Electricity pricing in China and the role of the State

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Abstract

Theoretical and empirical evidence is presented to show that inefficient power firms in China are subsidised by the state through the ability to charge high electricity prices and the creation of a "soft price constraint" on costs. This cost inefficiency challenges the merits of planned power supply.

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1. Introduction

The electricity or power generation sector in China is dominated by state owned firms, which accounts for some 95% of the installed power generation capacity in the economy (Kroeber et al, 2008). The liberalisation of power supply in China is based on: (i) the introduction of competition in capacity investment by removing barriers to entry, (ii) the decentralisation of investment decisions from the state to the state-owned power firm, and (iii) the commercialisation of the firms by making them accountable for profits. However, both power and grid companies continue to be controlled by the state in terms of price and production.[1]

Successful reform in liberalising market entry, which has stimulated capacity and output growth, has not been extended to other parts of the supply chain, such as power distribution and retail. Once capacity is built up, its productive use for power generation remains strictly regulated by the state on the basis of firm-level quantity and price (Wang, 2007; Liu, 2006). We propose that regardless of firm size or market power, the newly reformed state institution allows the firm to seek a high planned price via bargaining with the state for more compensation of its costs. This bargainable pricing behaviour of the firm creates a "soft price constraint" on costs in the price setting.

2. The Behaviour of the Planned Price and Derivation of Empirical Models

To stylise the theoretical debate, in line with the view made by Kornai (1992) for a classic centrally planned economy, we propose that the state planner sets a price in order to maximise the total output of the whole industry (Q) for a given set of resources available at time t (denoted as $\overline{p}_t$). This represents the aggregate planned price for the producer to sell electricity or power.

In a symmetric scenario, every power plant or firm would have an identical cost. In this case, the planner can set the planned price of each individual firm to equal the aggregate social planned price, i.e. $\overline{p}_{it} = \overline{p}_t$.

Given the heterogeneity of firms, however, costs are not identical. Thus the aggregate planned price is adjusted by the planner to reflect individual firm productive conditions and costs. This adjustment of the planned price to the cost of the firm at c_{it} can be described as follows:

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

or $$\overline{p}_{it} = \left[\overline{p}_t\right]^{\lambda} c_{it}^{1-\lambda} \qquad (1)$$

[1] See Bradley and Yang (2006), Lam (2004), and Andrews and Dow (2000) for further studies on China's electricity sector

where, λ is the cost adjustment coefficient for a planned price at a range between 0 and 1. If $\lambda=0$, the aggregate planned price is fully adjusted to equal the cost of an individual firm. If $\lambda=1$, then the aggregate planned price remains unchanged. Therefore, λ indicates the degree to which the aggregate planned price is adjusted to the cost of the firm. In other words, more adjustment leads to a higher firm's price (since more cost impacts are taken into account in setting up a planned price for the firm).

Furthermore, in equation (1), the aggregate planned price $\overline{p}_t$ can be transformed to be more specific by denoting the total output of the industry Q as the sum of the planned aggregate electricity output, q, and other industrial output, Q_j, produced by other industries in a free market, which is:

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

Since the state will attempt to set the aggregate planned supply of electricity (q) as much as possible to meet the output growth of other industries that demand electricity as a basic input to their production, q is a function of Q_j such that $q = q(Q_j)$ with the property that $dq/dQ_j>0$. Apart from the aggregate demand that affects planned supply, both in the short run and in the long run, a planned price also provides an incentive for the power firm to set its capacity of supply in the long run. Due to the firm's decision in setting its investment capacity (Rosen & Houser, 2007), the higher planned price can induce the firm to invest in more capacity, which will enable the state to have more capacity to plan more output q. This gives $q=q\lfloor Q_j(p),\overline{p}\rfloor$ with the property that $\partial q/\partial\overline{p}>0$. $Q_j(p)$ states that other industries operate in a free market and, as a result, their output is a function of the market price p with $\partial Q_j/\partial p<0$. On this basis, we write equation (2) as

$$Q = q\lfloor Q_j(p),\overline{p}\rfloor + Q_j(p) \tag{3}$$

If we consider an argument that the aggregate planned supply of electricity can also serve as 'a strategic constraint' on the output of other industries, which is notably the case where there is a shortage of power in an economy, then equation (3) can be augmented as:

$$Q = q\lfloor Q_j(p),\overline{p}\rfloor + Q_j\left[p,\, q(\overline{p})\right] \tag{4}$$

Taking into account the impact of electricity power costs or the planned price ($\overline{p}$) on the market price of other products (p), we maximise the total output of both electricity and other industries, Q (which is the objective of the state planner in choosing a planned price), giving the following:[2]

[2] This is in line with the view of Kornai (1992).

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

Manipulating above gives $\left[\frac{\partial q}{\partial \overline{p}}\frac{\overline{p}}{q}\right]\frac{q}{\overline{p}} = -\frac{\partial q}{\partial Q_j}\frac{dQ_j}{dp}\frac{dp}{d\overline{p}} - \frac{\partial Q_j}{\partial p}\frac{dp}{d\overline{p}} - \frac{\partial Q_j}{\partial q}\frac{dq}{d\overline{p}}$

Then the aggregate planned price becomes: $\overline{p} = \frac{\varepsilon}{\sigma} q$ (5.1)

$$where\ \ \varepsilon = \frac{\partial q}{\partial \overline{p}}\frac{\overline{p}}{q} > 0 \quad and \quad \sigma = \rho - \frac{\partial Q_j}{\partial q}\frac{dq}{d\overline{p}} \quad and \quad \rho = -\left[\frac{\partial Q_j}{\partial p}\frac{dp}{d\overline{p}} + \frac{\partial q}{\partial Q_j}\frac{dQ_j}{dp}\frac{dp}{d\overline{p}}\right] \quad (5.2)$$

In equation (5.1), ε is the price-incentive elasticity of output to reflect how a commercialised profit-making firm will respond to planned prices in choosing its capacity. The state plans output for a firm according to its capacity, such that the elasticity is expected to be positive (since the higher planned price will stimulate more capacity expansion and higher output). This suggests that $\varepsilon>0$ given that $dq / d\overline{p} > 0$.

The sign on σ is expected to be negative. Firstly, $\rho \leq 0$, at least in the short run. A change in electricity prices ($\overline{p}$) will not immediately lead to a change in the product price of other industries (p) due to: (i) product competition that can force the firm to internally absorb a cost rise as much as possible and (ii) the price adjustment made by the firm in response to costs will be lagged. As a result $dp / d\overline{p} = 0$ in equation (5.2). Therefore, we expect $\rho \leq 0$.

Secondly, the marginal output of other industries with respect to supply of electricity is positive, i.e. $\partial Q_j/\partial q>0$. This ensures that $\frac{\partial Q_j}{\partial q}\frac{dq}{d\overline{p}} > 0$, so that with $\rho \leq 0$ we expect $\sigma<0$ in equation (5.2).

The discussion above demonstrates the expectation of the negative relationship between the electricity price and the aggregate power quantity supplied. The negative relationship between the electricity price and the aggregate power quantity supplied implies that economic growth will be very much affected or constrained by power supply. This creates a strategic incentive for the state to plan not only an increase in supply but also at a lower cost to stimulate demand for power in order to increase the output of other industries and increase economic growth. Thus, in this setting, the promotion of economic growth helps to explain the regulation of electricity pricing and supply in China.

Through manipulation with equation (5.1), equation (1) then becomes:

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

Or in a non-linear form the above can be implicitly presented as:

$$\bar{p}_{it} = q_t^{\lambda \frac{\varepsilon}{\sigma}} C_{it}^{1-\lambda} \tag{6.2}$$

Where, $\varepsilon/\sigma<0$, the negative σ in equation (6.2) implies that the state intends to respond to the high reliance of economic growth on power by having more power supplied at a low cost for stimulating the higher output growth of other industries and thus the economy.

Regarding the cost impact on the price in equation (6.2), it is expected that the effect of an individual firm's cost on the price-setting will lead to a soft price constraint on the costs, resulting in a higher price due to the higher cost. Therefore, the cost is expected to be a key factor in affecting the planned price of a power firm. 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 use to bargain with or to influence the state in order to achieve a higher price.

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

In equation (7), *r* is the cost of capital that the firm can strategically raise (such as, for example, taking on more bank loans to finance its projects, or establishing a higher depreciation rate) in bargaining for a higher price to offset a part of the financial costs. A raw material or fuel price is denoted by *m* in equation (7), which indicates that the firm could ask the planner to pass its costs through due to a rise in input costs. The third element is the cost history of the firm, captured by the overall unit costs 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 bargaining process between the state and the firm. We also consider the profitability position of the firm that can affect its bargaining process with the state planner. In addition, it is also possible that the firm could use the costs of rival firms (c_j) as an indication of the cost environment in bargaining for a higher price. If the price is soft in terms of its constraint on costs, then it is expected that loss-making firms have a high price and the profit-making firms have a low price, i.e. this is the effect of the soft price constraint. In equation (7), *D* denotes the profitability position as 1 for profits and 0 for losses.

Using logarithms in equation (7), with the inclusion of a market share variable (*s*), the average cost of rival firms (c_j) and dummy variables for location (D^L) and affiliation (D^A), our empirical model of the planned price bargaining process becomes:

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

where μ is a disturbance term with a normal distribution, $\hat{\gamma} = \frac{\varepsilon}{\sigma}$, $\hat{\beta} = \beta(1-\lambda)$ and

$\hat{\eta} = \eta(1-\lambda), \hat{\phi} = \phi(1-\lambda), \hat{\theta} = \theta(1-\lambda)$.

In addition, we conduct a robustness test [see Column 3 of Table 1], based the interest rate (i_r) and depreciation rate (d_r) components of the cost of capital (r):

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

We also test the price margin (p^M) impact of the bargaining factors:

$$\ln\bar{p}_{it}^M = \alpha + \hat{\gamma}\ln q_{it} + \tau\ln s_{it} + \hat{\eta}\ln c_{jt} + \hat{\beta}\ln r_{it} + \hat{\phi}\ln m_{it} + \tau\ln LF_{it} + \omega d_t + \xi d_t^L + \kappa d_t^A + \nu_{it} \quad (10)$$

where LF is the loading factor, i.e. actual output over the capacity.[3]

[3] The loading factor enables us to test whether there is an effect of the soft price constraint on the profit margin in the planned price (since the state may allow the firm with the lower loading factor and higher unit cost to charge a higher profit margin in the price to offset the high cost).

3. Empirical Analysis of Price-Cost Bargaining Model

The results of empirical tests on equations (8), (9), and (10) are provided in Table 1.[4]

Table 1 What Determines Electricity Prices of the Power Firm?

	Log price				Log price margin			
	Equation (8)		Equation (9)		Equation (10)			
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
Intercept	1.989	1.4	2.427*	1.8	2.820***	3.7	2.837***	3.2
Total output of the region (log q_{t-1})	-0.059	-1.3	-0.321*	-1.9	-0.335***	-3.4	-0.335***	-3.0
Avg cost of the rival firms (log c_{jt})	0.415**	2.4	0.628***	4.4				
Cost of rivals, [log (c_{jt}/c_{it-1})]					0.100*	1.9	0.106	1.6
Market share of firm (log s_{it-1})	-0.007	-0.3	0.026	0.8	0.032*	1.9	0.038*	1.9
Lagged cost, (log c_{it-1})	0.155**	2.1	0.222***	3.6				
Cost of capital, (log r_{it})			0.049***	3.0	-0.016	-1.3		
In which, 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})	0.192***	4.0	0.277***	6.7	-0.100***	-2.7	-0.110**	-2.4
Load factor, (log LF_{it-1})					-0.124***	-3.2	-0.133***	-2.9
State of profit of the firm								
(1 for profit, 0 for loss)	-0.073**	-2.1	-0.127***	-4.0	-0.065**	-2.2	-0.059*	-1.8
Location of the firm								
(1 in Guangdong, 0 in others)	0.229**	2.5			-0.152*	-1.9	-0.147*	-1.7
Affiliation of the firm								
(1 with central, 0 with local)	-0.178	-1.5	-0.309***	-2.6	-0.190*	-1.9	-0.181	-1.6
R^2 (adjusted)	0.950		0.980		0.662		0.612	
Standard Error of estimation	0.110		0.118		0.098		0.105	
No. of observations	180		191		191		180	
Firms	96		99		99		96	

Note: Firm specific fixed effects are controlled for using firm dummies. ***, **, and * denote statistical significance at the 1%, 5% and 10% levels respectively.

[4] Annual data was attained from the National Bureau of Statistics of China and the Electricity Annals of China (2005, 2006). These sources of data enabled the construction of a 3-year panel for 110 power firms over the period 2003 to 2005. An on-grid price is the dependent variable for model (8) and (9). The prices used are calculated from annual sales revenue of electricity divided by the volume sold per year. For model (10), and the price margin is the dependent variable, calculated using the sales revenue divided by the total costs of the firm. Full details on all of the variables used in the analysis are available from the authors upon request.

As shown in Table 1, firm profitability is negatively related to both the price and the price margin. This suggests that the state plans a lower price for profitable firms and sets a price higher for less profitable firms. The price subsidises loss-making firms through authorising them the right to charge more. Evidence of the soft price constraint on costs can be further shown by the sign of the loading factor variable: a higher price margin is granted to firms with lower capacity utilisation.[5]

As explained by our price bargaining model, the sign of the aggregate output (q) coefficient reflects the importance of electricity to the economy. A negative sign indicates that the Chinese economy is in a development stage where economic growth is highly responsive to power supply, since the marginal output of the power is high. This creates a growth-driven incentive to the state to increase power supply but at a cheaper price in order to stimulate demand for power. Our estimation shows that this incentive becomes dominant in the planning of the power supply.

However, the intention of the state to maximise output by having more supply of electricity at a lower price in favour of demand is subject to the cost constraint that can affect the sustainable development of the power industry. This is shown in Table 1, where all cost-related variables are significantly and positively related to the price.[6] Summing the coefficients of the three cost variables minus the coefficient of the price impact of demand gives a net cost impact of 0.756 (=0.415+0.155+0.195–0.039) for equation (8), and 0.806 (=0.628+0.212+0.277 – 0.321) for equation (9). The net cost impact means that an increase in price by 0.8% occurs in response to 1% increase in the total costs after taking into account the demand pressure on lowering the price of the power supply. Thus, the cost dominates the price bargaining, so the planned price becomes an outcome of balancing the different interests of various parties.

4. Conclusions

The price of electricity is planned by the state to maximise the total output of the economy through supply of more power at a lowest possible cost that the power firms can produce safely and sustainably. To ensure sustainability, the compromise of public interests is made by having the soft price constraint on costs in the price setting. This induces the firm to take the high cost strategy that helps its fundraising and price bargaining with the state.

The state subsidises the loss-making firms by giving them the right to charge a higher price. This protects inefficient firms at the expense of the profitability of the grid firm that buys power at the higher planned price but sells at the lower price. To reduce the losses of the grid firm, the pressure to raise the sale price for the end-users is created. The cost inefficiency shadows or even offsets the merits of the reformed planned supply: first, to stimulate rapid capacity investment from both public and private sectors; secondly, to play an effective role as

[5] See Lopez and Salies (2006) and Bateson and Swan (1989) for further evidence of this effect for developed economies.

[6] These variables are the cost of rival firms (c_j), the lagged cost effect of the firm on price adjustment (c_{t-1}), and fuel inflation (m).

‘a price stabiliser’ in stabilising the inflationary impact of the energy price on the economy; thirdly, to promote economic growth; and, finally, to induce transaction cost savings for the middle traders by internalising trade. Apparently, resolving the cost inefficiency caused by the distorted pricing behaviour remains a challenge for China going forward.

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