



# Deregulation, vertical unbundling and the performance of China's large coal-fired power plants<sup>☆</sup>



Xiaoli Zhao<sup>a</sup>, Chunbo Ma<sup>b,\*</sup>

<sup>a</sup> School of Economics and Management, Institute for Low Carbon Economy and Trade, North China Electric Power University, Beijing, China

<sup>b</sup> School of Agricultural and Resource Economics, Centre for Environmental Economics and Policy, University of Western Australia, Crawley, WA 6009, Australia

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## ABSTRACT

In 2003, China's integrated electricity utility – the State Power Corporation (SPC) – was unbundled and dismantled into five generation groups and two grid companies in an effort to increase competition and improve efficiency. In this paper, we study the impact of this deregulation reform on the operational efficiency for a balanced panel of 34 large power plants for the period 1997–2010. We find that on average these power plants have converged to the technological frontier over the sample period. Controlling for substantial heterogeneity in the technical profile, we also find that the unbundling reform has boosted productivity of China's large thermal power plants; however, the presumably differential impacts of the reform on the previously SPC-managed power plants and the independent power producers in our sample are insignificant.

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## 1. Introduction

The unbundling reform in China's electricity sector was introduced in 2002 and took effect in 2003. The reform built on the same efficiency rationale that is employed in the decentralization and unbundling policies of electricity sectors in many other economies – that is, to break the vertical monopoly and increase the competition on the generation side. As a result of the reform, China's former vertically integrated electricity utility – the State Power Corporation (SPC), was dismantled into 11 companies including 5 generation groups. The reform had a direct impact on the operation of previously SPC-managed power plants as they now no longer enjoy the privilege of being part of a vertical monopoly but have to face the same competition as the independent power producers (IPPs) do. The reform may also have indirect impact on the IPPs as the competition maybe intensified. A comparison of operational efficiencies between previously SPC-managed power plants and

IPPs would reveal these different impacts and indicate whether the unbundling reform has achieved its target. Such an analysis must also consider possible influences of other policy measures. Any systematic differences caused by other policy changes must be controlled for. Particular attention will be focused on the “Small-Unit Shutdown Mandate” (SUSM), the “Promoting the Big and Quashing the Small Policy” (PBQSP) and the “Flue Gas Desulfurization Mandate” (FGDM). All three policies have been introduced in recent years to address the environmental concern and upgrade the generation technology in the electricity sector. As we explain later in the paper, these policies have also affected the operational efficiency of power plants in different ways which need to be controlled. With a rich collection of plant-level covariates, we are able to disentangle these influences and examine the impacts of the reform. The remainder of this paper proceeds as follows. Section 2 discusses the evolution of China's regulatory reforms in the electricity sector. Section 3 reviews previous studies on production efficiency of the electricity industry. Section 4 introduces the double bootstrap data envelopment analysis. Data collection is described in Section 5. Section 6 presents the results and discussion. The last section concludes.

## 2. Regulatory reforms in China's electricity sector

Before 1985, China's electricity sector was vertically integrated, centrally invested and managed by the Ministry of Electricity Power (MEP)

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\* Corresponding author. Tel.: +61 864882534; fax: +61 864881098.  
E-mail address: [chunbo.ma@uwa.edu.au](mailto:chunbo.ma@uwa.edu.au) (C. Ma).

and many regional Bureaus of Electricity Power (BEP). The MEP and BEPs were essentially part of the central and local governments but playing multiple roles as investor, manager and regulator. Under the old administrative scheme, all new generation capacity was centrally invested, which had constrained the country's electricity sector for decades. There was an urgent need for additional investments to expand the capacity to meet the increasing demand driven largely by the accelerated economic growth. The power sector reform in 1985 aimed to remove the capital bottleneck by changing the investment institution to allow diverse investment sources. Local governments, domestic enterprises and foreign investors have since been allowed to form independent power producers (IPPs). This was regarded as the main theme of the 1985 reform. However, the MEP remained the dominant investor, manager and regulator of the electricity industry, which was typical of most industries that were dominated by state owned enterprises (SOEs) at the time. Due to a soft budget constraint, the incentive to improve operational efficiency was rather weak.

As part of the economy-wide reform of Chinese SOEs aiming to separate the role of business manager from that of governmental regulator, the government launched a second major regulatory reform in the electricity sector in 1997. The main theme of this reform was to break the MEP into an independent electricity enterprise and an independent market regulator, or in Chinese terms – *Zheng Qi Fen Kai*. As a result, the MEP was dismantled and its administrative and regulatory functions were transferred to the State Economic and Trade Committee (SETC), which performed as the overarching regulator of all industries at the time. A new public utility – SPC – was established as the independent electricity enterprise. The SPC then took over all generation, transmission and distribution assets previously managed by the MEP. However, the vertical integrated structure remained.

The vertical integration was finally unbundled in 2003 when the SPC was dismantled into 11 new corporations including five generation corporation groups, two grid corporations and four auxiliary corporations. Each of the five generation groups manages a large number of power plants (hereafter referred to as “GROUP” plants). By the end of 2010, the five generation groups controlled about half of total national generation capacity. Other state-owned generation enterprises, local government, domestic private enterprises and foreign-invested enterprises own and manage the other half capacity (SERC, 2010). The reform aimed to remove the monopoly of the SPC and introduce competition on the generation side (Ma and He, 2008), or again in Chinese terms – *Chang Wang Fen Kai*. It was also hoped that the right to dispatch power would be based on economic efficiency and merit order rather than political factors such as protection of state-owned assets and employment. China's regulatory authority expects that the unbundling and deregulation reform would eventually increase the competitiveness and improve the overall productivity performance of China's electricity industry.

### 3. Deregulation, market structure and efficiency

There have been extensive studies on the effect of electricity sector deregulation and unbundling on efficiency. The majority of the studies have found that increased competition and unbundling may work to improve efficiency. For instance, Newbery and Pollitt (1997) have documented generator efficiency gains from restructuring Britain's Central Electricity Generating Board. A transition from a state-owned monopoly to a privatized and competitive generation market resulted in significant efficiency gain in the labor input. Using plant-level data, Hiebert (2002) estimates a stochastic frontier production function to study the effect of U.S. restructuring over the period of 1988–1997 and finds substantial efficiency improvement for coal-fired power plants in states that restructured in or before 1996. Fabrizio et al. (2007) found public owned plants whose owners are largely insulated from market competition, experienced the smallest efficiency gains, while investor-owned plants in states that restructured their wholesale electricity markets

improved the most. Cross-country studies also provide evidence on the benefit of deregulating the electricity sector and restraining the exercise of market power. Using a panel data on 19 OECD countries over a 10-year period, Steiner (2000) find that while changes in legal rules may be slow to translate into changes in conduct, unbundling of generation and the introduction of electricity markets have a positive and significant impact on most performance measures including power prices. Hattori and Tsutsui (2004) conduct a study on the same 19 OECD countries while come to the conclusion that the unbundling of generation does not necessarily lower the price, which differs from Steiner (2000). Based on original panel data for 83 developing countries, Nagayama (2007) also finds that the unbundling of generation on its own does not always reduce the electric power price; however, coexistent with an independent regulator, unbundling may work to reduce power prices.

Given the large scale of China's electricity sector, its coal-dependent nature, and its significance to national energy security and the global community with regards to the control of climate change, a sound understanding of impacts of recent reforms and productivity performance of the sector becomes increasingly important. There have been extensive discussions of the reforms and policies recently introduced in China's electricity sector; however, few studies have been devoted to quantifying the impacts of China's recent regulatory reforms and policies on the efficiency of power generation based on detailed micro analyses. Lam and Shiu (2004) applies a data envelopment analysis (DEA) approach to province-level data to assess the productivity growth of thermal power industries over the period of 1995 to 2000 with a focus on the regulatory reform in 1997. The results show that technological change accounts for almost all the TFP growth and provinces with an electricity sector not dominated by SPC have achieved higher levels of technical and scale efficiency. Yang and Pollitt (2009) also examine the productivity performance of Chinese coal-fired power plants based on a cross-section sample of 221 plants in 2002; however the focus of the paper was primarily on the relative performance of different DEA-based models rather than on the impact of regulatory reforms. Du et al. (2009) are the first to investigate the impact of the unbundling reform in 2002 on China's electricity generation efficiency using a differences-in-differences (DID) approach. The study is based on two cross-section plant-level national survey data collected in 1997 and 2004 and they find significant input efficiency improvement in labor and non-fuel materials but not in fuel input. More recently, Gao and Biesebroeck (2011) provide the first parametric firm-level panel evidence and confirm the efficiency improvement due to the unbundling reform. Both Du et al. (2009) and Gao and Biesebroeck (2011) follow the estimation approach in Fabrizio et al. (2007).

Our study builds on the existing literature and particularly extends Lam and Shiu (2004), Du et al. (2009) and Gao and Biesebroeck (2011). Results from Lam and Shiu (2004) suggest potential efficiency benefits from replacing regulated monopoly with a market-based industry structure. With the previously vertically integrated monopoly SPC being divested in 2002, the time is ripe now for an investigation whether such benefits have materialized or not. While Du et al. (2009) are the first to show the efficiency improvement due to the unbundling reform and Gao and Biesebroeck (2011) further confirm this finding with panel evidence, our study differs in several ways. First, Gao and Biesebroeck (2011) use firm-level panel data collected through annual surveys by China's National Statistical Bureau of Statistics. The panel data we use is at the plant level which is collected through annual surveys by regulatory authorities in the electricity sector. In some cases, an electricity firm may operate more than one plant. In addition, our panel data covers a longer period. Second, Du et al. (2009) and Gao and Biesebroeck (2011) study efficiency improvement in materials and labor by estimating parametric demand functions. In this paper, we take a nonparametric approach which has the advantage that it does not need to assume particular functional forms.

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