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## Firm-level determinants of energy and carbon intensity in China

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## HIGHLIGHTS

- We describe China's Eleventh Five-Year Plan energy policies.
- We examine the drivers of energy, electricity and carbon intensity reduction.
- Higher electricity prices correlated with reductions in industrial electricity intensity.
- Energy intensity reduction efforts were effective at reducing carbon intensity.

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## ABSTRACT

In recent years, China's leaders have sought to coordinate official energy intensity reduction targets with new targets for carbon dioxide (CO<sub>2</sub>) intensity reduction. The Eleventh Five-Year Plan (2006–2010) included for the first time a binding target for energy intensity, while a binding target for CO<sub>2</sub> intensity was included later in the Twelfth Five-Year Plan (2011–2015). Using panel data for a sample of industrial firms in China covering 2005 to 2009, we investigate the drivers of energy intensity reduction (measured in terms of direct primary energy use and electricity use) and associated CO<sub>2</sub> intensity reduction. Rising electricity prices were associated with decreases in electricity intensity and increases in primary energy intensity, consistent with a substitution effect. Overall, we find that energy intensity reduction by industrial firms during the Eleventh Five-Year Plan translated into more than proportional CO<sub>2</sub> intensity reduction because reducing coal use—in direct industrial use as well as in the power sector—was a dominant abatement strategy. If similar dynamics characterize the Twelfth Five-Year Plan (2011–2015), the national 17 percent CO<sub>2</sub> intensity reduction target may not be difficult to meet—and the 16 percent energy intensity reduction target may result in significantly greater CO<sub>2</sub> intensity reduction.

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## 1. Introduction

Against a backdrop of growing concern about local air pollution and global climate change, China's industrial firms have come under increasing pressure to reduce the intensity of energy use and carbon dioxide (CO<sub>2</sub>) emissions associated with their operations. Policymakers in China are actively debating the choice of measures to support energy savings and CO<sub>2</sub> emissions reductions at the enterprise level. Target setting in China defines firm-level quotas based on national targets for reducing the energy and, more recently under the Twelfth Five-Year Plan (2011–2015), the CO<sub>2</sub> intensity of economic activity.

Energy intensity and CO<sub>2</sub> intensity are related but not synonymous. If all energy sources are subject to an energy intensity target, reducing energy intensity may inadvertently reduce low

carbon energy sources alongside fossil fuels. However, energy use may be easier for firms to monitor and report using existing tools and procedures. Given the interest in identifying straightforward, effective, and measurable targets for achieving CO<sub>2</sub> emissions intensity reductions, we ask how well targeting energy intensity has performed in reducing CO<sub>2</sub> intensity.

Understanding the challenges of targeting energy intensity, CO<sub>2</sub> intensity, or both simultaneously is important as China designs its next generation of policy. China has signaled that it will continue to implement top-down national initiatives by defining targets at the level of provinces, industries, and firms through the Thirteenth Five-Year Plan (2016–2020). At the same time, the introduction of new market-based instruments, such as an emissions trading system or tax for CO<sub>2</sub>, which would price energy-embodied carbon, is under discussion. Emissions trading pilot programs are currently under way in two provinces and an additional five cities, and accompanied by efforts to strengthen reporting and verification of energy use and CO<sub>2</sub> emissions at the enterprise level nationwide.

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Using a detailed panel data set that includes observations of 747 firms spanning 15 industries and six provinces from 2005 to 2009—we investigate factors that energy, electricity, and CO<sub>2</sub> intensity at the firm level during the Eleventh Five-Year Plan (2006–2010). We also consider how changes in direct energy use and electricity use influence the overall CO<sub>2</sub> intensity reduction that firms achieved.

This paper is organized as follows. Section 2 provides background on China's industrial energy use and energy management policies. Section 3 describes our data set and the econometric specifications. Section 4 investigates diversity in energy management practices at the firm level and examines correlations between potential drivers and outcomes using regression analysis. Section 5 summarizes the conclusions and offers directions for future work.

## 2. Background

To provide context for our analysis, we first provide a brief overview of China's energy system and industrial energy use. We then describe the history of efforts to manage economy-wide and industrial-sector energy use, with a focus on recent efforts in place during the Eleventh Five-Year Plan.

### 2.1. China's industrial energy use and trends

China's industrial sector is responsible for the largest share of the country's end-use energy demand, accounting for 73 percent in 2010, as shown in Fig. 1. (China State Council, 2012). Over the period of 2005–2010, energy use by the industrial sector alone increased from 1.6 billion tons of coal equivalent (tce) to around 2.4 billion tce (China State Council, 2012). Industrial energy use is comprised of energy embodied in electricity demand as well as direct fossil fuel use, much of which is consumed in the manufacturing sector. Some of the most CO<sub>2</sub>-intensive industries are iron and steel (30 percent), chemicals (16 percent), cement and other non-metallic minerals (15 percent), petroleum refining (9 percent), and smelting and pressing of non-ferrous metals (7 percent), which together accounted for more than 75 percent of total manufacturing-related CO<sub>2</sub> emissions in 2010 (CESY, 2011).

A breakdown of China's primary energy use in historical perspective shows the country's sustained and substantial reliance on coal, about half of which is used in electric power generation and one-quarter of which is used directly by industry (Fig. 2). Qi et al. (2012) calculate China's CO<sub>2</sub> emissions based on fossil fuel use by sector and find that around 22 percent is associated with the country's net exports. The government has recently enacted policies aimed at reducing the share of energy-intensive exports, for instance by reducing export tariff rebates on energy-intensive

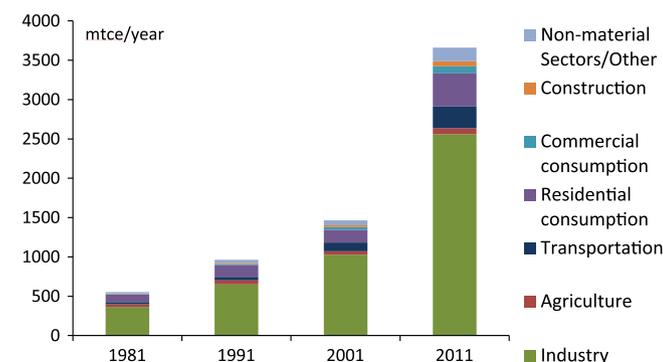


Fig. 1. Breakdown of end-use energy consumption in China (China Energy Statistical Yearbook, 2011). (mtce—million tons of coal equivalent).

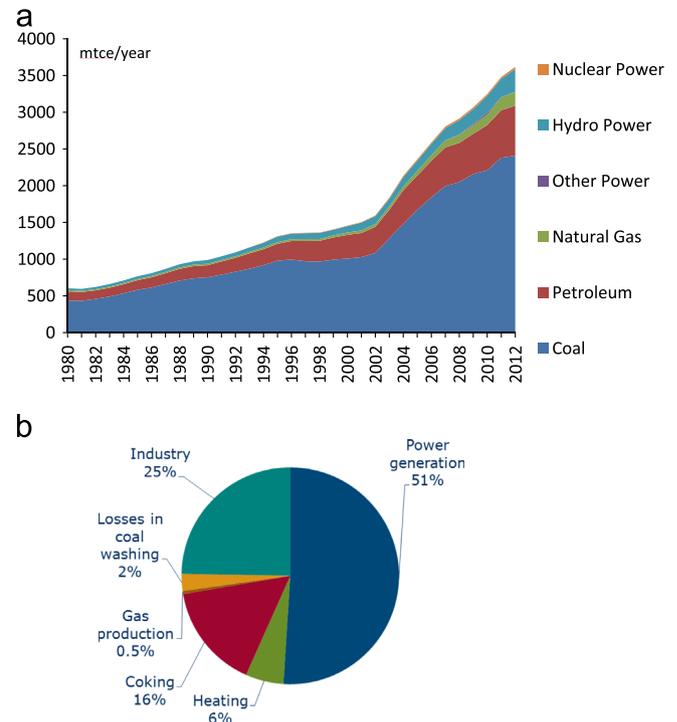


Fig. 2. Overview of the composition and trends in total primary energy and coal use in China: (a) primary energy use (1980–2010), (b) breakdown of coal use in China by sector (2010).

goods (China State Council, 2011). These measures are seen as consistent with national goals of managing dependence on exported growth and raising the contribution of domestic consumption to GDP (Deer and Song, 2012).

### 2.2. National energy policy and its impact on firm energy management

National initiatives aimed at reducing energy intensity have been a mainstay of China's energy and environmental policy for several decades, although targets have not always been binding. The energy intensity of China's economy improved continuously from 1980 to 2005 (Ma and Stern, 2008), even though there were no binding targets in place for energy intensity reduction.

The Eleventh Five-Year Plan signaled a redoubled commitment to addressing energy intensity and, in the Twelfth Five-Year Plan, CO<sub>2</sub> emissions intensity was included for the first time. The Eleventh FYP targeted a 20 percent reduction in energy intensity at the national level, which was then translated into targets for individual provinces and industries, including energy-intensive enterprises. At the end of the Eleventh Five-Year Plan, the government reported that the energy intensity target had been achieved, with an economy-wide energy intensity reduction of 19.1 percent.<sup>1</sup> The decline in demand for exports of energy-intensive commodities during the global economic crisis contributed to the achievement of the energy intensity target.

Energy intensity targets in the Eleventh Five-Year Plan (and energy and carbon intensity targets in the Twelfth Five-Year Plan) are implemented in a top-down fashion, through the allocation of targets to provinces and sectors, then to the cities and enterprises. During the Eleventh Five-Year Plan, the provincial targets were set based on a rapid assessment of potential reduction opportunities

<sup>1</sup> The 20 percent reduction was intended to be approximate (Levine et al., 2010).

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