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Analysis

# Relocation or reallocation: Impacts of differentiated energy saving regulation on manufacturing industries in China

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ABSTRACT

Unilateral tightening of environmental regulation is often considered to cause regulated industries to locate at places with lower compliance cost. The pollution haven effect may be offset, however, when endogenous technical change and factor reallocation can compensate increased compliance cost. This paper identifies the overall effects on industrial activities from provincially differentiated regulation of energy saving in China. Econometric specifications take into account the workings of different policy instruments, quantity and revenue-based measurement of output, policy-induced price effects, and alternative measurement of productivity and competitiveness. Results indicate that an introduction of energy-saving policies leads to loss of output and productivity in energy-intensive industries initially, which is passed on to other industries via markets of capital and energy-intensive goods. Under higher regulation, energy-intensive industries become more capital-intensive, regain productivity more quickly, and increase export rates; other industries become more labor-intensive, recover more slowly, and decrease export rates. Through capital investment and factor reallocation, China's policy has been effective in improving industrial energy efficiency without causing competitive loss or carbon leakage. An incentive-based instrument of differential electricity prices leads to similar effects on industries, implying the possibility for more efficient policy-making.



## 1. Introduction

Inter-jurisdictional differences in environmental or climate policies are often considered a driving force for spatial redistribution of industrial activities. As the pollution haven effect suggests (Copeland and Taylor, 2004; Brunnermeier and Levinson, 2004), tightening regulation unilaterally causes regulated sectors to bear higher production cost for compliance, to locate to regions with laxer regulations, and to have lower export and higher import, and causes factors of production to be allocated to unregulated sectors. Therefore, an economy with tightened regulation would suffer loss of productivity and employment, and experience transitional cost in reallocating production and workers. Relocated polluting activities reinforce the environment problem in unregulated regions, and undermine the policy objective of reduced emissions. Domestic policy effectiveness can also be damaged, if the regulated pollutant causes environmental externalities outside national borders (Bushnell et al., 2008). In the extreme case, climate change causes global externalities, and the location of greenhouse gas emission does not matter to the magnitude and distribution of its externalities.

Alternative views about environmental policies and industrial competitiveness exist. Both Porter's dynamic view of comparative advantage (Porter and Van der Linde, 1995) and endogenous technical change (Popp, 2010) suggest that properly designed environmental regulations spur innovation and may improve competitiveness of regulated sectors in the long run. Recent analytic models show that, in the short term, policy-induced input substitution and change in factor prices can sometimes cause negative emission leakage (Karp, 2013; Fullerton et al., 2013). Even if technological change and factor reallocation cannot fully offset loss of competitiveness or emission leakage due to environmental regulation, ignoring the former effect would lead to overestimation of negative policy impacts of environmental policies, and may motivate further policy distortion, for example in the form of border tax adjustments.

Although many early empirical studies find insignificant or ambiguous evidence for the association between environmental regulations and industrial location, competitiveness, and trade (Brunnermeier and Levinson, 2004; Jaffe et al., 1995), recent findings on the Clean Air Act Amendments (CAAA) in the US are extensive and consistent. The effect of nonattainment status for a county under CAAA has been confirmed to be negative and significant on polluting firms' location (Henderson, 1996; Becker and Henderson, 2000; List et al., 2003), their growth (Greenstone, 2002), employment (Walker, 2011), productivity

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(Greenstone et al., 2012), and overall county manufacturing activity (Kahn, 1997). The regulation caused US-based multinational firms to increase their foreign production (Hanna, 2010). Estimated cost of reallocating the workforce because of nonattainment designation under CAAA was far below the estimated benefits, but was much larger than the transition assistance allocated under the regulation (Walker, 2012).

Most of the literature about carbon leakage from unilateral climate policies is ex ante and measures the size of positive leakage based on computable general equilibrium models. Depending on the policy scenarios, the estimated leakage usually ranges between 2% and 20% (Burniaux and Martins, 2012), with the extreme scenario of 130% (Babiker, 2005). Empirical research is thin. It shows that Kyoto commitments reduced domestic carbon emissions and exports, but not carbon footprints, with the gap between domestic consumption and production made up by carbon leakage (Aichele and Felbermayr, 2012, 2013); energy efficiency standards more consistently and significantly caused negative impact on industrial competitiveness than carbon taxes (The World Bank, 2008); in the US, higher electricity price reduced employment both in energy-intensive industries in a county (Kahn and Mansur, 2013) and collectively for a state (Deschenes, 2010).

For a comprehensive understanding of policy effects on industrial location, factor allocation and technical change, the research of this paper empirically investigates the association between provincially differentiated energy-saving regulations in China and changes of industrial sectors in output, input, factor substitution, and productivity, based on a dataset of 20 two-digit manufacturing sectors across 29 provinces during 2005–2010. It differs from previous literature in several ways. First, as an emerging market, China features greater potential for technology adoption and faster capital turnover than the developed countries on which pollution haven research previously focused. This implies lower compliance cost and motivation for relocation. Meanwhile, market barriers are lower domestically between provinces, so that policy-induced changes in industries, if any, can be more easily observed. Second, given that a climate policy usually features a comprehensive package of mixed policy measures, we explicitly differentiate the impact of energy-saving regulation from that of energy pricing and energy endowments. Third, we not only examine policy effects on common measures of industrial scale, such as output, employment, and capital stocks, but also effects on capital–labor ratios and productivity. This leads to a more comprehensive understanding of the policy impact on industry location, factor allocation, and technical change. Fourth, to separate direct policy impacts from indirect ones of changes in price and market condition, we explore for two cases – steel and cement production – policy effects on physical output, prices and revenues. Fifth, we compare policy effects on multifactor productivity and international competitiveness to explore the global impact of China's energy saving policy.

Our findings show that the initial implementation of high energy-saving regulations caused a shock to productivity and output of energy-intensive industries, which was passed on to other industries through markets of capital and intermediate goods. Energy-intensive industries responded to the regulations by greatly increasing their capital stock and partially substituting capital for labor, while other industries adjusted in the opposite way, possibly because of higher capital rents and lower wages driven by investment in energy-intensive industries. Over the four years of regulation, all industries, especially the energy-intensive ones, recovered from the initial loss. Employment loss and capital accumulation in energy-intensive industries, however, continued. More capital-intensive production led to improved competitiveness and increased export rates in energy-intensive industries. Like energy-saving regulations, differentiated electricity prices caused factor reallocation but not industrial relocation. Only electricity surplus might be a driver of relocation, for all industries.

These findings suggest that environmental and climate policies do not necessarily function as deterrents on output: estimation of policy impact tends to be biased if not considering factor reallocation and substitution in regulated sectors, inter-sectoral interactions in factor and intermediate goods markets, or revenue-based output change due to price change. China's current policy framework that combines energy saving with compensatory measures and spatial differentiation is effective in bringing energy efficiency improvement with only temporary productivity loss and no significant industrial relocation. In general, even when border adjustment is not used, domestic emission reduction can be achieved without leakage or competitiveness loss via properly designed regulations and incentives.

The remainder of the paper is organized as follows. The next section briefly introduces relevant energy-saving policies in China. Section 3 explains the use of data and estimation strategy. The results are reported in Section 4. Section 5 extends the benchmark estimation in Section 4 by considering alternative specifications for estimation, quantity and revenue-based measures of output in steel and cement industries, and alternative measures of productivity and competitiveness. The paper closes in Section 6 with a brief synopsis and conclusion.

## 2. Energy Saving Policy in China

China experienced a continuous decrease of energy consumption per unit GDP from the 1980s to 2002, which, however, was then reversed. With the reversal of energy-intensity decrease and surging total energy demand, the national government announced a series of guidelines, policies, and programs for energy saving, mostly for industries (Appendix Tables A1 and A2). The overall national policy target was a 20% reduction of energy consumption per unit GDP – or energy intensity – by 2010 as compared to 2005, which was proposed in November 2005 and officially included in early 2006 as a target of the 11th National Five-Year Plan. These policies are characterized by two features — comprehensive use of multiple energy saving measures and policy instruments, and spatial differentiation in policy implementation and stringency.

### *2.1. Multiple Energy-saving Measures and Policy Instruments*

Law and general guidelines, ratified by the legislature and central administrative authority (Appendix Table A1), authorized multiple measures for industrial energy saving. These measures include target-setting for energy saving and disaggregation among administrative divisions, energy consumption standards for industrial processes and products, firm-level energy-saving assessments, target-setting, plans and supervision, promotion of energy-saving innovation, information, and technology adoption, industrial structure adjustment and elimination of outdated production capacity, as well as the development of incentive-based policies to support energy saving. These energy-saving measures have been supported by detailed policies and programs designed by central and local governments (see Appendix Table A2 for typical policies and programs by the central government).

The energy-saving measures are promoted through multiple policy instruments in implementation, including mandatory, voluntary, and incentive-based ones, as well as information disclosure requirements. Industrial structure adjustment and capacity control is enforced through mandatory elimination of production processes based on certain technologies or below certain energy efficiency standards. Firm-level target setting and planning for energy saving can be considered as voluntary, featuring a negotiation process between firms and local government. Energy-saving projects and adoption of qualified technologies are supported by incentives, including financing support, investment subsidies, reward, and tax breaks. Information disclosure is also used to reveal energy-saving progress of major energy consumers. Mixed use of multiple energy-saving measures and policy instruments makes unclear the aggregate policy impact, which, however, can be identified from spatial differentiation in energy-saving regulation.