Chain Reactions: How Chinaâ€™s Environmental Random Inspections Drive Green Innovation Through Industrial Linkages and Regional Spillovers

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Author: Meitong Ren

This study examines the impact of Chinaâ€™s environmental random check policy on green technology innovation through industrial linkages and regional heterogeneity, employing an integrated framework that combines a multi-regional input-output (MRIO) model with an extended spatial Durbin model. Leveraging panel data from 29 Chinese provinces (2006â€“2015), including provincial environmental penalty records, sector-level green patents (mapped via IPC-industry classification), MRIO tables, and pollution intensity indicators, we analyze how regulatory enforcement drives innovation diffusion and pollution relocation across supply chains. Methodologically, we innovate by constructing sectoral linkage-based spatial weight matrices to replace conventional geographic or economic distance weights, and we use the matrix to capture inter-sectoral dependencies. Instrumental variables (historical pollution data) and policy simulations (e.g., sector-specific inspection adjustments) address endogeneity and validate robustness.

This study conducts analysis from two perspectives: horizontal and vertical. Horizontal analysis refers to the input-output extension of spatial spillover effects, and quantifies the industrial transfer and technological innovation spillover of random inspection policies among provinces and regions in China. A multi-regional input-output model (MRIO) is constructed, and combined with the results of the spatial Durbin model in existing studies, the direct impact of environmental protection penalties in the eastern region on the acceptance of high-polluting industries in the western region, as well as the inhibitory effect of green technology innovation caused by this, is analyzed. The pollution transfer mechanism is explained through industrial chain linkage, such as the polluting enterprises eliminated in the eastern region drive the expansion of related industries in the western region through the demand for intermediate products, and its long-term impact on regional innovation capabilities is evaluated. Vertical analysis refers to the analysis of environmental regulation effects in the upstream and downstream of the industrial chain, and studies how environmental protection policies affect green technology innovation through the upstream and downstream relationships of the industrial chain. Using input-output tables, high-polluting sectors (such as steel and chemicals) and their upstream and downstream related industries are identified. Green patent data are classified by sector to study the heterogeneous effects of random inspection policies on technological innovation of directly regulated sectors and their related sectors. The "ripple effect" of policies generated through the supply chain is revealed, and the phenomenon that upstream enterprises adopt green technologies and force downstream enterprises to innovate synchronously is found, explaining the transmission mechanism.

It anticipates revealing significant sectoral heterogeneity: high-pollution sectors (e.g., steel, chemicals) are expected to exhibit stronger local green patent growth compared to low-pollution sectors. However, the demand for intermediate products may exacerbate pollution displacement, potentially suppressing innovation in western regions. Industrial linkages are likely to amplify spatial spillovers, with eastern regionsâ€™ reliance on resource-intensive sectors in the west potentially widening regional innovation gaps. The expectation for simulations are to indicate that targeted inspections in â€œhub sectorsâ€• (e.g., environmental equipment) could enhance supply chain-wide green patent growth while mitigating cross-regional pollution transfer.

Theoretically, this research advances the Porter Hypothesis by proposing a â€œpolicy-industry chain-innovationâ€• framework, elucidating how environmental regulation propagates innovation through supply chains. Methodologically, it pioneers embedding input-output networks into spatial

econometrics, enabling multidimensional policy evaluation. Practically, it advocates â€œprecision chain-based regulationâ€•â€”dynamic adjustments of inspection intensity based on sectoral linkages and regional capacitiesâ€”coupled with cross-regional governance coordination. These findings offer actionable insights for aligning environmental regulation with sustainable development, highlighting the potential of policy synergies (e.g., carbon markets with random checks) to further enhance industrial green transitions.