Impacts of Cobalt Supply Chain Disruption Risks on China's Energy-Economic Transition

Topic: Input-output Modelling and Supply Chain Resilience (II)
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China aims to achieve carbon neutrality by 2060. Electric vehicle (EV) promotion is pivotal; in 2023, EV adoption saved approximately 17 million tons of refined oil. While the EV value chain drives economic growth, China's 98% import dependency on cobaltâ€”a critical raw materialâ€”exposes the economy to stochastic shocks and tail risks amidst geopolitical volatility.

To systematically evaluate how cobalt supply chain shocks influence Chinaâ€™s energy-economic transition, this study constructs a 2023 Social Accounting Matrix (SAM) for China that explicitly incorporates cobalt resources. This research further updates the Dynamic Recursive Chinese Computable General Equilibrium (DRCCGE) model , developed and maintained by the Development Research Center (DRC). Building upon this framework, the study integrates cobalt production and supply mechanisms and embeds a risk distribution function specifically for the cobalt supply chain. This approach allows for a rigorous estimation of the Conditional Value at Risk (CVaR) stemming from global supply disruptions and delineates the transmission pathways of these risks within the domestic economy. The specific details are as follows:

Firstly, this study constructs a 2023 SAM based on the latest input-output tables and statistical data from the National Bureau of Statistics (NBS), utilizing 2023 as the base year for the calibration of the DRCCGE model. Specifically, by synthesizing data on cobalt material flows, production cost structures, and international trade patterns, the paper disaggregates the "cobalt ore factor" and the "refined cobalt sector" within the SAM, which are subsequently integrated into the DRCCGE model.
Secondly, to simulate carbon neutrality pathways, this study extends the DRCCGE model by disaggregating the electricity sector while concurrently accounting for mitigation technologies (e.g., CCS) and policy-based abatement measures such as carbon taxes. In parallel, a cobalt supply mechanism is integrated to account for price responsiveness and resource constraints, and a production function is developed to capture the demand rigidity of cobalt in power battery manufacturing. Consequently, the modelâ€™s nested hierarchy is modified and a targeted parameter calibration is performed.
Thirdly, to capture the stochastic nature of cobalt supply risks, this study departs from the traditional deterministic single-event assumption and innovatively proposes a CGE framework incorporating a risk distribution function. Referring to studies by Liu et al. (2025) and Van den Brink et al. (2020) , this research constructs a Bayesian Network for the cobalt supply chain by compiling global mining data, customs data, and transaction data published in the financial reports of refined cobalt enterprises. This network fully accounts for the risk resilience of suppliers at all levels across the value chainâ€”from overseas mining to domestic refining. Coupled with Monte Carlo simulations, the study evaluates the CVaR and the cumulative probability distribution of the impacts of supply chain disruptions. Specifically, the CVaR corresponding to this risk distribution is translated into the supply

constraint of the cobalt ore factor within the model. This constraint is then introduced into the DRCCGE model to map the dynamic macroeconomic and energy-environmental impact distributions from 2023 to 2060.

Findings are presented across three dimensions:
(1) Aggregate Impacts: Relative to the baseline, we analyze the distribution of GDP losses, carbon abatement costs, and confidence intervals for energy sources under extreme shocks.
(2) Transmission Pathways: Using price multiplier mechanisms, we delineate structural paths through which shocks propagateâ€”from battery cost fluctuations to EV market price hikes, ultimately affecting industrial structure, profit distribution, and employment.
(3) Characteristic Shifts: The study reveals how slowed EV expansion leads to transitory fossil fuel dependence and necessitates adjustments in the energy mix and CCS deployment, reflecting cobalt's long-term restrictive role in carbon neutrality.

This study fills the gap in quantifying systemic impacts of cobalt supply risks using a dynamic IO-CGE framework. The results provide a scientific basis for early-warning mechanisms and coordinated energy transition strategies under resource constraints.