National Network
for Critical
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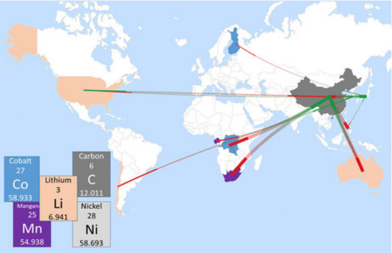
Opportunities for Battery Material Supply Chain Resilience and Sources of Vulnerabilities

Research Issue



The significant transformation involved in the electrification of the automotive industry is expected to put continued pressure on battery material supply chains. The location and ownership of these supply chains are largely concentrated in a limited set of countries and could be at risk of global conflict, natural disasters, and trade disputes. These supply frictions may create disruptions to the U.S. automotive industry that could impact U.S. households, employment, and manufacturer competitiveness. This analysis quantifies the impact of future scenarios of concern on the battery material supply chain for U.S. consumers, manufacturing labor, equity, and the economy and identifies policies that reduce the risks and impacts of these scenarios. Our assessment has three main components: (1) quantifying effects of global material supply scenarios on the price and availability of critical battery material inputs, (2) estimating the impacts of the resulting material price hikes or material shortages on the U.S. automotive industry, and (3) quantifying the impact on the prices and sales of new vehicles in the U.S., battery and automotive manufacturing employment, consumer welfare, and U.S.-based manufacturer competitiveness. Our analysis will also qualitatively identify the opportunities and challenges for policies and investment options that could increase supply chain resiliency and mitigate impacts.

Methods and Data

The approach combines (1) interviews and literature review to form scenarios that are grounded in current mining concerns and historical mineral supply disruptions, (2) global material supply and demand curves constructed using estimates of projected mine capacities, and (3) simulations of the U.S. automotive market using an oligopolistic equilibrium model. The materials supply and demand models we develop are built on previous work by the Olivetti Group and the Materials Systems Lab at MIT. Using historic data on material demand, prices, mining production, and mining costs, we generate future demand and supply curves for each of the at-risk critical materials to identify the “marginal” price of the materials under future scenarios. Under the baseline scenario without disruptions, the mining supply matches the projected demand. When supply disruptions occur, the supply curve is modified according to the defined scenario and a new price is estimated based on the supply-demand equilibrium after accounting for the short-run price elasticity of mines and consumers. For each scenario, material prices are inputs to battery material prices (e.g. lithium manganese-nickel-cobalt or NMC, lithium-iron-phosphate or LFP, lithium nickel-cobalt-aluminum or NCA) using established cost models (Hsieh et al., 2019; Mauler et al., 2021), and we use BatPaC (v 5.0) to determine the resulting BEV battery pack production costs. Then, Carnegie Mellon estimates how manufacturers would respond to these changes and estimates the benefits of supply-chain resiliency investments. The changes in vehicle prices and output allow us to estimate impacts on consumers, workers, and manufacturers, including average effects and equity concerns.

Insights

Supply of several critical elements used in BEV cathodes (including lithium, cobalt, graphite, and nickel) are at risk of not matching expected demand increases in the near term. An important constraint to supply is the time needed to bring mining capacity online (5-8 years from discovery). Moreover, processing of these materials is currently concentrated geographically or financially in China, which creates a vulnerability to tariffs or trade disputes between the U.S. and China. A key insight for lithium is that the U.S. does have enough lithium deposits to meet future demand, but that bringing that supply online is dependent on permitting timelines and the U.S.' willingness to onshore more mining and refining operations. A key insight for nickel is that there is an opportunity for supply-side technologies to fill the gap between available battery-grade nickel and demanded battery-grade nickel. Refining lower grade nickel to battery grades is incredibly carbon-intensive, but finding a more environmentally friendly way to refine it would open many more nickel sources for battery consumption. A key insight for cobalt is that it is highly concentrated in the DRC, which leaves it open to natural disaster vulnerabilities. Additionally, some DRC cobalt is associated with human rights abuses in its mining practices, which could induce supply frictions for the U.S. if they chose to prevent artisanal mined cobalt from entering the U.S. Frictions in the cobalt market have the potential for the greatest price spikes, but battery manufacturers can substitute away from cobalt in batteries. A key insight for graphite is that China owns much of the graphite market, but the U.S. does have a domestic synthetic graphite market. If China was to impose an export ban on graphite like its rare earth elements export ban in the 2010s, the U.S. would have room to shift away from natural graphite and shift towards synthetic graphite. This is a more expensive option, but this substitution protects the U.S. from the dramatic price increases seen historically with rare earth elements.

Policy Choices under Consideration

Broad policy options we will consider include providing additional incentives for domestic extraction, investing in supply-side technologies, streamlining mining permitting processes, and incentivizing R&D for alternative battery chemistries. Each of these options has its own challenges and benefits. For example, incentives for U.S. extraction secures U.S. supply chains of battery materials but has the potential to impact our climate goals by building new supply chains, which is time-consuming and costly. Policymakers can balance this tradeoff by diversifying our supply chains for battery materials. Streamlining mine permitting could increase domestic production in time to avoid supply chain risks in the near term, but policymakers must balance this benefit with potential environmental damages to local communities, particularly indigenous communities, and ensuring stakeholder participation in the permitting process. Expanding materials reserves can provide a buffer against supply frictions in the short-term, but reserves do not solve systemic undersupply issues. Investing in supply-side technologies can be a long-term solution to systemic undersupply issues and provide additional flexibility in materials markets. Policies resulting in expanded U.S. lithium mining and processing would provide BEVs with LFP batteries more insulation from global material supply shocks due to global conflict and trade disputes, whereas today's dominant BEV battery chemistry, NMC, would not be as resilient. While manufacturers currently favor NMC for its performance advantages, investments in R&D in LFP batteries could potentially increase performance and encourage further adoption of those batteries.

Next Steps: Upcoming work and plans for integration by September

Over the next three months we will finalize the full project report to be published by the end of August. Finalizing the report will include updating the report with lessons learned from the Q3 NNCTA meeting, integrating feedback from advisory council review, and further refining our vision for the future of critical technology assessment. We will share key findings and the completed published report with interview participants to show them the results of their time and expertise spent with our team. We will continue to coordinate across the MIT-CMU energy storage team to identify key challenges and opportunities to mitigate the effects of supply chain shocks and frictions. We will also gather insights from our NNCTA peers to apply their best practices to energy storage and we will share our findings that are relevant to critical technology assessment more broadly.