National Network for Critical Technology Assessment

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Future Battery Material Supply Issues Can Substantially Impact US Car Prices and Consumers

Research Issue

The electrification of the automotive industry will put continued pressure on battery material supply chains. If efforts are not taken to increase the resiliency of the industry to global material supply issues, the markets for these materials may create disruptions to the U.S. automotive industry that could significantly impact U.S. consumers, employment, and vehicle production. This analysis quantifies the impact that future scenarios of concern for battery material supply would have on U.S. consumers and automotive manufacturing. We also identify measures that could reduce the impacts of these scenarios.

Methods and Data

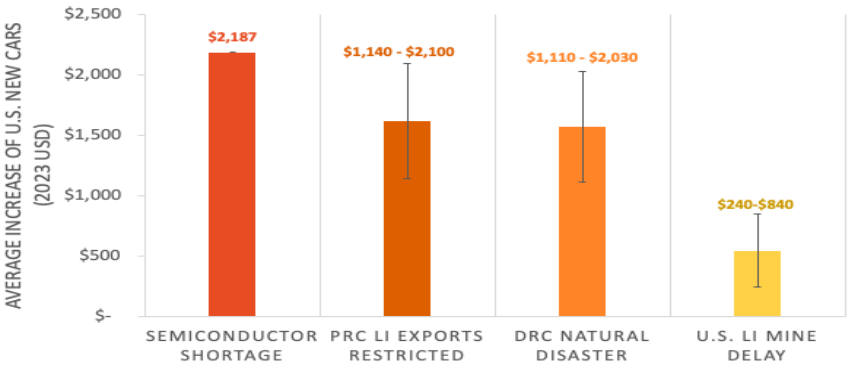
We simulate the U.S. automotive market using an oligopolistic equilibrium model with three key inputs: (1) global battery material supply and prices estimated by the MIT Critical Materials team for multiple potential future scenarios that would increase material prices, (2) U.S. new vehicle characteristics data from the National Highway Traffic Safety Administration (NHTSA), and (3) consumer preference for new vehicles in the U.S. estimated from Forsythe et al. (2023). The consumer survey in Forsythe et al captures mainstream consumer preferences between ICE vehicles and BEVs with future technological capabilities by mimicking consumers comparing vehicles on automaker websites and retail sites like Edmunds.com. Respondents were currently in the market for a new car or SUV or had purchased one in the previous year; the weighted sample population is representative of the U.S. new car and SUV buying population along household income, age, education, gender, and household size. The impact of material prices on the cost of battery electric vehicle (BEV) battery pack production is calculated using the BatPaC (version 5.0) model, developed by Argonne National Laboratory. Automakers' BEV offerings are expected to increase dramatically within the next decade, with projections of BEVs reaching 40-50% of new vehicle sales by 2030. In our baseline simulations, we represent the expected increase in availability and variety of BEV options available in 2030 by assuming that each internal combustion engine (ICE) vehicle in the NHTSA data has a BEV counterpart with the same performance, features, style, and other characteristics as the ICE vehicle. We estimate how increases in battery production costs in each scenario will impact vehicle prices and production quantities using a partial-equilibrium model of the U.S. automotive market where each of the top 17 automakers set their vehicle prices to maximize profit while facing production capacity constraints that limit the amount they can increase the production of ICE vehicles in their existing plants to counteract rising BEV production costs. This approach represents the short-term (i.e., 1-2 year) impact of the scenarios, before suppliers and automakers are able to alter production plans or supply chains in response to the material price increases. We perform sensitivity analyses of the model results to assumptions of the consumer demand model, the number of vehicles in the market, and the increase in production capacity of ICE vehicles that is possible and do not find that the estimated vehicle price increases change significantly. Details are available in the Supporting Information.

Insights

In our baseline scenario representing the BEV technological capabilities projected to be available by 2030, approximately 50% of new car purchases and 30% of new SUV purchases in the U.S. are BEVs. This is meant to represent an optimistic projection of BEV availability in 2030 where no battery material supply chain shocks or delays occur. As described in the Critical Minerals demo summary, interviews were conducted with automakers, material experts, and mining companies to identify a set of future potential material supply scenarios of concern. Out of these scenarios, three scenarios are provided as demonstrative cases, showing two scenarios with relatively large impacts and one scenario showing smaller impacts on the automotive industry and U.S. consumers from the set of identified scenarios. Additionally, for the first scenario (where we see the largest impacts on average vehicle prices), we simulate a potential intervention to demonstrate that if additional materials supply was available, the increase in new vehicle prices would be substantially mitigated. Supporting extra supply through mechanisms like recycling or alternative extraction technologies will create buffers against disruptions, which can reduce the increase in vehicle prices. However, actions to increase supply may also impact profits of existing mines, which could impact the market. These effects will be examined in future work.

Lithium Restrict

In this scenario, processed lithium from China is subject to a reduction in export quotas by 30%. This scenario mimics the rare earth mineral trade dispute that occurred in 2012-2015. Under this scenario, the per kilowatt-hour cost of battery manufacturing increases by approximately 25%. This drives the price of BEVs up and increases consumer demand for ICE vehicles. As a result, in the short-run (i.e., 1-2 year) market equilibrium, the average price of all new vehicles—including both BEVs and ICE vehicles—increases by $1,620 [$1,140 to $2,100] for cars and $2,120 [$1,500 to $2,730] for SUVs.[1] Calculations of consumer surplus find that, on average, every car buyer is worse off by $348 [$250 to $440] and every SUV buyer is worse off by $720 [$520 to $920]. These figures imply an annual total loss across all consumers of $24 billion [17.3 to 30.5] while vehicle manufacturer operating profits decrease or increase by less than 2%.



In addition to the price increases, between 500,000 and 900,000 U.S. households are unable to purchase a new vehicle for each year that the price hike continues. This represents a contraction of new vehicle sales in the U.S. by 5.3% [3.8% to 6.8%]. BEV sales drop 14% [10.0% to 17.9%] under this scenario. This drop in

[1] The lower and upper bounds represent the effects of the 95% confidence interval of material prices that result from the scenario. Further details of these calculations are provided in the Critical Mineral demo summary.

production could affect up to 18,500 [13,400 to 23,700] labor-months of lost wages considering battery cell and pack production-line workers alone.

Figure 1: New car price increases from the future scenarios in comparison with the semiconductor shortage

As shown in Figure 1, the estimated impact of this scenario on the automotive market is similar in magnitude to that of the semiconductor shortage that began in 2021. The price increase and drop in production of new vehicles that occurred with the semiconductor shortage created large increases in used vehicle prices and U.S. inflation. Correspondingly, although we do not model used vehicle prices or inflationary effects in this analysis, we would anticipate similar concerns under this future potential scenario.

Lithium Restrict Intervention

We find that if an additional supply (at any price) of 100kt of lithium was made available (e.g. though recycling, alternative extraction, strategic reserves), it would reduce the increase in average vehicle price in the Lithium Restrict scenario by more than 80% in both the car and SUV markets. New vehicle sales drop less than 1% and BEV sales drop only 2.2%.

Cobalt Restrict

A second scenario that has large impacts is if natural disasters reduce cobalt production from DRC mines by 65kt. In this case, the price of U.S. new cars increase by $1,570 [$1,110 to $2,030] and SUVs by $2,120 [$1,500 to $2,730] with similarly large impacts on manufacturing workers and U.S. households.

Lithium Delay

In another scenario, delays in U.S. lithium mining development cause 250 kilotons of projected lithium supply to not be available by 2030. This scenario has a smaller impact on the automotive market. Production costs for 300 mi battery packs increase by $740 and the average new car price increases by $540. In this scenario, over 100,000 U.S. households are unable to purchase a new vehicle for each year the price hike persists.

Potential Measures to Mitigate Effects

The estimated impacts of future lithium supply chain shocks and delays could be potentially mitigated by ensuring adequate stock of the strategic lithium reserve and/or incentivizing the expansion of lithium extraction and processing in the U.S. and other countries that would not be at risk of export restrictions. The guidance proposed by the IRS and Treasury Department that limit BEV tax credits for vehicles with batteries that contain critical minerals extracted or processed by a foreign entity of concern are expected to incentivize supply chains in this direction.