Industrial Policies for Multi-Stage Production: The Battle for Battery-Powered Vehicles

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Abstract :
Many countries have implemented policies to promote transition from combustion engines to electric vehicles (EVs). As batteries constitute about one third of the cost of EVs and are costly to transport, firms need to establish low-cost battery supply chains in order to make EVs attractive to consumers. At the same time, governments increasingly use tax and subsidy schemes to induce firms to place more stages of the supply chain within their jurisdictions. We specify a multi-stage supply chain for EVs from battery cell production to vehicle distribution. Each car producer selects where to open facilities at each stage considering production costs, trade costs, and subsidies. This is a difficult combinatorial choice problem that cannot be solved using existing "squeezing" algorithms that have been used in the recent literature analyzing global supply chain location choices. Instead, we use a mixed integer linear program formulation that can computationally solve our real-scale multi-stage application in seconds. We use this method to estimate the parameters of our model—which include the variable production costs and fixed plant/model activation costs—using observed sourcing decisions for all production stages over the period 2015 to 2023. We then investigate counterfactual simulations for different types of industrial and trade policies and describe how those affect the production location choices across the global chains for EVs and the trade patterns from battery through assembly to final consumption destinations.