The Electric Vehicle Transition
and the Economics of Banning Gasoline Vehicles

Stephen P. Holland, Erin Mansur, Nicholas Z. Muller, and Andrew J. Yates

Two changes have recently altered markets in personal transportation dramatically. First, the introduction of the Tesla Roadster in 2006 marked a modern resurgence in sales of electric vehicles. In Norway, electric vehicles (EVs) surpassed 60 percent of new vehicle sales and are expected to exceed 90 percent by 2024. In the US, EV sales are currently less than 10 percent of sales, but are projected to exceed 90 percent of sales in California by 2040. This growth has been fueled by public policies and by technological advances, for example in batteries. Second, the US electricity grid has become dramatically cleaner. The authors' forthcoming study, "Decompositions and Policy Consequences of an Extraordinary Decline in Air Pollution from Electricity Generation," shows that the decline in total emissions from 2010 to 2017 led to a decline in damages in the East of about 5 percent per year. Public subsidies for EVs have played a role in increased environmental benefits from EVs, which should increase as electricity becomes cleaner.

These two changes raise questions about the optimal transition to EVs. Should the transition wait until EVs become cleaner, or should EVs be built in anticipation of their environmental benefits? Under what conditions would a ban on gasoline vehicles be socially optimal? This last question arises because several countries are considering bans on the sale of new gasoline vehicles within the next few decades: Norway in 2025, India in 2030, and Britain and France in 2040.

Holland, Mansur, Muller, and Yates address these questions with a theoretical model of the EV transition. The authors construct an optimal control problem for a planner who determines the production levels for gasoline and EVs over time to maximize welfare. Welfare includes the consumer benefits from using vehicles, the costs of producing them, and the pollution damages and other costs associated with their use.

The model accounts for the important dynamic aspects of EV adoption. First, the model allows for declining damages from EVs as described above. Second, the model allows for declining production costs of EVs. Prices of EVs have typically been $20,000 to$30,000 higher than comparable gasoline vehicles primarily due to the high costs of batteries. However, production costs of EVs have declined dramatically. Third, vehicles are durable goods. The model captures stock effects of production and depreciation for both electric and gasoline vehicles. Finally, the model can analyze complementary infrastructure for EVs such as charging stations. Complementary infrastructure increases the utility of EVs, and thus changes the degree of substitutability between the vehicles.

The authors first consider whether a ban could be optimal given the economic fundamentals in the model. A simple condition under which the planner optimally bans production of gasoline vehicles in the long run depends on the substitutability of gasoline and electric vehicles, the long-run production costs of the vehicles, and the long-run pollution damages. Intuitively, if EVs are good enough substitutes for gasoline vehicles, banning gasoline vehicle production in the long run could be optimal.

The authors then characterize the optimal transition to EVs. If electric and gasoline vehicles are perfect substitutes, it is optimal to stop production of gasoline vehicles before EVs are produced. In the more realistic case in which vehicles are not perfect substitutes, production of EVs optimally begins when production plus externality costs of the EV fall such that the marginal rate of substitution equals the full cost ratio between electric and gasoline vehicles. Production of gasoline vehicles may later cease if the vehicles are sufficiently close substitutes.

The authors calibrate the model for the United States. Numerical simulations show that the optimal time to implement a ban on gasoline vehicle production in the United States is quite sensitive to the parameters that characterize the substitutability of EVs for gasoline vehicles. For many values of the parameters, the ban on gasoline vehicle production occurs well after 2030, if it occurs at all. The authors also simulate the business-as-usual (BAU) case in which the planner ignores the externalities from air pollution from both gasoline and electric vehicles. Finally, the authors analyze the welfare benefits of several types of subsidies on the purchase of EVs.