THE DYNAMIC COSTS & BENEFITS OF TECHNOLOGY-FORCING POLICY NESTED IN A BROADER PERFORMANCE STANDARD: THE CASE OF ZEV & CAFE

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Overview

When a regional technology-forcing policy, such as a state Zero-Emissions Vehicle (ZEV) mandate, is implemented in the presence of an existing broader technology-neutral environmental performance standard, such as the federal Corporate Average Fuel Economy (CAFE) standards, indirect and complex costs and benefits can occur. Two types of these effects are policy interaction effects, such as leakage from nested policies (Goulder, Jacobsen, & Van Benthem, 2012; Jenn, Azevedo, & Michalek, 2016), and long-term dynamic effects, such as spillover of cost reductions (Gillingham & Stock, 2018; Linn & McConnell, 2017; Fox, Axsen, & Jaccard, 2017)**.**

Policy interaction effects can erode the direct policy benefits of a technology-specific policy. In situations where policies are nested (i.e. overlapping in jurisdiction and/or scope), emissions may "leak" into other regions and/or into the part of the fleet that faces lower stringency. This results in a lack of complete additionality for these policies and associated emissions reductions. When the fleet-wide emissions performance is already governed by fixed and binding CAFE standards, electric vehicles (EVs) and nested ZEV quotas may not produce their expected environmental benefit. However, despite their potentially limited direct benefit, technology-forcing policy may still indirectly reduce emissions after accounting for dynamic effects and positive externalities. For EVs, these include spillover of non-appropriable learning-by-doing and economies of scale, R&D spillover and induced innovation, and network effects.

The literature lacks a detailed understanding of the complex costs and benefits of nested technology-specific policy such as ZEV. Policy alternatives are typically analysed in isolation, one at a time, and complex standards and regulations are compared against market-based instruments such as carbon taxes or EV subsidies. This can fail to account for nested policy interaction effects. Factors such as fuel economy performance are exogenously and independently assumed, implicitly ignoring the impact of EVs and EV policy on fuel economy performance and policy. Meanwhile, the benefits and costs of standards and regulations are typically assessed in a direct manner, accounting for short-term emissions reductions and the static costs to consumers, producers, and government. Meanwhile, the benefits of dynamic effects are inadequately studied or considered. The overall impact of both policy interaction and dynamic effects together is unclear in direction and magnitude. This study investigates the combined role of dynamic and policy interaction effects on the benefits and costs of ZEV quotas nested in CAFE standards.

Given the primacy of CAFE standards in driving environmental outcomes, ZEV policies may produce limited direct benefits, but they may generate indirect benefits via dynamic effects by either (1) inducing change to future CAFE policy stringency or (2) causing future CAFE policy to cease to bind. This study allows the dynamic effects of ZEV to be indirectly realized via the endogenous tightening of CAFE standards that would lead to improved environmental outcomes (first mechanism). This study also considers scenarios and conditions where EVs and ZEV policy might cause CAFE overcompliance i.e. non-bindingness (second mechanism).

Methods

This study simulates the US light duty vehicle market with a model with consumers and state governments in each of two regions (ZEV and non-ZEV regions), and automakers and federal government for both regions. Consumers are assumed to maximize random utility while choosing vehicle alternatives in a mixed logit demand framework. Automakers are assumed to maximize profit while deciding the pricing and design for their differentiated product portfolios, subject to both ZEV and CAFE policies modelled as constraints. Automakers are modelled to be in oligopolistic competition and equilibrium.

This study represents several interactions between ZEV and CAFE policies and technology costs explicitly and endogenously. The federal policymaking process is modelled as a stylized version of how CAFE standards are set in the real world. CAFE standard stringency is set and updated based on net societal benefit, which balances externality mitigation with technology cost. An exogenous range of ZEV policy pathways is tested. Policy interaction is explicitly accounted and analysed, to show how much emissions leakage may occur between segments of automaker portfolios and across regions.

The model also simulates the dynamic effect of EV technology cost reduction. The model simulates increasing returns from past EV production and sales. The major endogenous dynamic effect is approximated by an exponential learning curve for EV battery pack costs with variable learning rates, and other dynamic cost reductions include approximations for learning-by-doing in the production of other EV components, economies of scale, induced innovation, and network effects that reduce future costs or barriers of EV adoption. The model distinguishes between the appropriable and non-appropriable portions of these effects, as well as the baseline/exogenous portions of these effects, and tests ranges of parameter values. Spillover effects are distinguished between those across-firm, across-region, and across-year (time steps). Exogenous dynamic effects were tested in a sensitivity analysis, including improvements in EV technology over time, improvements in fuel efficiency technology over time, and electric grid emissions intensity.

Results

This study compares the changes in overall costs and benefits relative to the base case of exogenous CAFE/GHG and ZEV, and between other cases to understand the effects of the new mechanism of endogenous CAFE standard setting, quantifying those GHG reductions made possible via ZEV-policy-induced cost reductions. This study also compares results within cases, across scenarios with exogenous ranges of values for parameters/variables, to understand patterns and trends and possible magnitudes of critical values of parameters such as the technological learning rate or spillover rate that might make or break the cost-benefit analysis outcome. Sensitivity analysis is also used to investigate uncertainty in the many parameters in this model.

We expect, due to policy interaction and leakage, that in the near-term the GHG impact of ZEV policy will follow or exceed the GHG emissions expected from a CAFE-standard-only scenario. This might be combined with potentially higher GHG emissions from charging from the electric grid. We expect the near-term societal costs such as reduced consumer and producer surpluses will outweigh the near-term benefits. However, over time, we might see a switch in the sign of GHG and net benefits as a result of tightened CAFE standards that is induced by EV cost reductions.

Conclusions

This study addresses the complexity of dynamic effects and nested policy interaction in the benefit-cost analysis of technology-specific policy. The simulation in this study demonstrates a new perspective of considering both effects together (better reflecting the existing policy situation) and a new method of modeling policy endogenously. The simulation quantifies the indirect impacts of ZEV quotas nested in CAFE standards and helps characterize the important trade-offs and critical parameter space that may inform policy decisions.

References

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