The Impacts of the Rebound Effect on U.S. CAFE Standards for Light-Duty Vehicles

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• In 2011, U.S. fuel economy regulations (CAFE) were increased from 27 to 54.5 MPG by 2025 as measured by the CAFE standard rules
  – Cars: annual 5% increases from 2017-2025
  – Light-duty trucks: annual 3.5% rise from 2017-2021, pushing upward to 5% from 2022-2025

• Research Objective: Compare the impacts of recent increases in CAFE regulations with an equivalent CO₂ tax. In addition, we observe how the rebound effect could potentially offset some of the expected benefits from fuel economy improvements.
• The rebound effect in transportation refers to increases in energy consumption as a result of a decline in driving cost due to increased fuel economy, and not the changes in fuel prices.

• Studies (A. Greening et al., 2000; Small and Dender, 2006; Sorrell et al., 2009) have suggested that improvements in vehicle efficiency does in fact result in both a short- and long-term rebound effects.

• The transportation sector is responsible for roughly 33% of domestic emissions. Therefore, possible emissions related to the rebound effect should be considered.
Our study makes the following two contributions to the existing literature:

1) We use the MARKAL model along with econometric rebound approximations to assess its potential to erode the benefits of CAFE increases, and the overall impact on the U.S. energy system.

2) We model the rebound effect – described as more of a short-term occurrence or changes in consumer behavior – within the MARKAL models’ long-term conceptual framework.
Simulation Model - MARKAL

- 2010 U.S. EPA MARKAL (MARKet Allocation) Model & National MARKAL Database (EPANMD)

- The model is a demand-driven, dynamic, linear programming, partial equilibrium model which optimizes by configuring the least-cost pathway for the overall energy system, while simultaneously maximizing total surplus.

- The model is characterized by its considerable detail regarding both the supply and demand sides of the energy system.

- Energy service demands (e.g. vehicle miles traveled (VMT)) are elastic.
Simulation Model - MARKAL

(Taken from Shay et al., 2006)
Modeling Assumptions

• Our focus will be on VMT demands for light-duty vehicles only. All other demands for energy services will be equivalent to reference case demands (inelastic).

• We correct for consumer myopia – a consumers’ inability to make completely rational decisions (Small, 2012) – by assuming that drivers are completely knowledgeable of lower driving costs related to higher CAFE standards.

• Penalty fines plus public relations costs for non-compliance will always be higher than the additional costs incurred from increasing the fuel efficiency. (Shiau et al. 2009)
Model and Data Modifications

The following are three primary adjustments made in this study to the 2010 U.S. EPA MARKAL database and model, some of which were taken from Sarica & Tyner (2012):

1) The model operates under higher expectations of natural gas supplies at lower costs.

2) We model only the NHTSA CAFE requirements in the model, or the improvements strictly related to fuel efficiency.

3) Studies (Hughes et al., 2006; Tyner and Taheripour, 2008; Yeh et al., 2008) have provided an adequate proxy for the price elasticity of VMT demand (0.10).
Scenarios

• **BASE:** Existing CAFE regulations in place are those prior to increases established by President Obama in 2011. All service demands (including light-duty demands for VMT) are calibrated relative to EIA’s 2010 Annual Energy Outlook report.

• **CAFE-ELAS:** Short for CAFE MARKAL Elastic Demands, this scenario captures Obama’s 2011 increases to existing fuel economy regulations. New regulations require an increase from 27 to 54.5 MPG by 2025 for LDVs.
Scenarios

• **CAFE-RBND:** In addition to CAFE increases, the rebound effect is considered. We draw upon estimates from the literature (Greene, Kahn et al. 1999; Small and Van Dender 2005; Small and Van Dender 2007) for estimates of the short-run rebound effect. Adjustments to the MARKAL framework are made to reflect consumer recognition a potential rebound effect of approximately 10%.

• **CO₂-TAX:** This scenario covers the application an economy-wide carbon tax capable of achieving a similar level of emission reductions as CAFE-ELAS. The tax does not specifically target the transportation sector emissions like the CAFE-based scenarios.
Modeling the Rebound Effect

- Rebound induced changes in short-term driving behavior is modeled using an iterative approach.

- **Initial Iteration**: compares average short-term fuel costs (driving costs) in the BASE case to the new driving costs resulting from implementing the higher fuel economy (CAFE-ELAS).

- **Following Iterations**: short-run driving costs are compared between the most recent iteration and the one prior. As usage rates increase with each iteration, further use of the efficient vehicle set will increase.

- **Stopping Criteria**: based on changes in the average fuel expenditures per vehicle between the iterations. A new equilibrium will be observed as changes in driving costs converge to zero (-.05% < change in fuel cost per vehicle < .05%).
Results/Discussion

VMT Demands by LDV fleet

Billions of vehicle miles (bn-vmt)

2015 2020 2025 2030 2035 2040 2045

2,500 3,000 3,500 4,000 4,500 5,000

BASE CAFE-ELAS CAFE-RBND CO2-TAX
Results/Discussion

Total Fuel Cost for the LDV Fleet

2000$ U.S. Billion

2015 2020 2025 2030 2035 2040 2045

- BASE
- CAFE-ELAS
- CAFE-RBND
- CO2-TAX
Results/Discussion

Average Annual Fuel Cost per Mile

2000$ US

2015  2020  2025  2030  2035  2040  2045

BASE  CAFE-ELAS  CAFE-RBND  CO2-TAX
Results/Discussion

Total Costs per LDV
Results/Discussion

CO₂ Emissions (Transportation)
Conclusion

• Relative to BASE, increases in CAFE cause significant reductions in total fuel costs, with our CO₂ tax increasing total fuel expenditures. However, CAFE increases generate higher capital costs associated with the purchasing of more efficient, more expensive vehicles – increasing total vehicle cost levels.

• Consequences of a rebound effect will lead to only slight variations in per mile (driving) and per vehicle fuel costs among the CAFE scenarios. However, VMT demands are considerably higher in our rebound case.

• Reductions in transportation sector emissions are achievable under all three policy cases. The rebound effect will only distort very little the abatement efforts of CAFE.
Conclusion

• The level of the CO$_2$ tax equivalent has proven to be ineffective in deploying more efficient vehicles for use in the transportation sector.

• Because an economy-wide tax takes advantage of the less costly abatement options from other sectors, the tax will generate the least amount of abatement within the transportation sector.

• We suggest that the fears of policymakers that any additional driving given the rebound effect will offset some of the anticipated benefits of fuel economy improvements are not warranted.
Questions?