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The Effect of Monetary Incentives on Sales of Advanced Clean Cars in the United States:

Summary of the Evidence

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Consumer Challenges

Achieving energy and climate goals will require a transformation of the transportation sector to vehicles and fuels that have low-to-zero lifecycle emissions. According to the National Research Council (2013), reducing greenhouse gas (GHG) emissions from light-duty vehicles by 80 percent by 2050 can best be achieved with strategies that lead to the large-scale commercialization of zero emission vehicles— both hydrogen fuel cell vehicles (FCVs) and plug-in electric vehicles (PEVs). The same study estimated that the public and private benefits resulting from the large-scale deployment of FCVs and PEVs would exceed the costs by an order of magnitude. Comprehensive strategies that engage technical and social processes have the potential to bring about the necessary innovations and overcome early market challenges needed for the value proposition of these vehicles to be fully competitive with internal combustion vehicles without the need for incentives.

One key element often contemplated within the strategies referenced earlier is to offer monetary incentives. Studies find that reducing the relative cost of owning PEVs and FCVs through monetary incentives or other means increases the likelihood that consumers will buy these vehicles—particularly if incentives are well designed and communicated. We discuss below some of the evidence that helps understand what incentives are most effective and efficient to support the market adoption of advanced clean vehicles.

The "why" behind the buys

The reasons why consumers decide to buy advanced technology vehicles include financial considerations, perceived environmental benefits, fondness for new technology, and a host of affective factors (e.g. Ozaki and Sevastyanova, 2011). Recent studies suggest that economic factors weigh more heavily than environmental attitudes on the likelihood of consumers to buy electric vehicles (Egbue and Long, 2012; Hidrue, et al., 2011). The body of scientific work generally referred to as consumer choice modeling continues to be the standard for quantifying the extent to which different factors affect consumer vehicle choices (for example, Bunch et al., 2000, Collantes, 2010, Hidrue, et al., 2011; Ramea et al., 2013; Greene and Liu, 2014). Obviously, not all consumers are affected by each factor in the same way. Santini and Vyas (2005) suggested modeling these differences across consumers by differentiating between earlier adopters and the rest of the consumers. The study by Hidrue, et al. (2011) indeed shows that the impact of each factor on the likelihood of buying an electric vehicle varies depending on the consumer segment examined.

Surveys, modeling and empirical studies reveal that the financial factors customers consider when purchasing a vehicle are directly influenced by the retail price, the availability of monetary incentives, as well as the structure of these incentives. Much of the evidence relates to hybrid electric vehicle (HEV) sales, with a number of studies already available for the case of PEVs. Examples of findings from these studies include the following:

• Hidrue, et al. (2011) find that the segment of consumers with electric vehicle (EV) adopter characteristics would pay $4,853 to avoid a one dollar increase in the price of a gallon equivalent of fuel, while the rest of the consumers would pay only $499. One way to interpret this result: If the price of a gallon of gasoline increased by one dollar, electric vehicles would become about $4,853 cheaper, relative to a conventional vehicle alternative, in the eyes of consumers with EV adopter characteristics.

• Krause et al. (2012) observe that 82 percent of the subjects of their study reported to be more likely to consider buying a plug-in electric vehicle if state and/or local incentives were made available to them.

• Jenn et al. (2013) find that the tax credit passed in the Energy Policy Act of 2005[1] had a highly positive effect on hybrid sales. Specifically, the study finds that hybrid sales increase by 0.0045 percent per dollar of incentive.[2] Furthermore, the study also reveals that this positive impact is concentrated in hybrids with high fuel economy, which received incentives over $1,000. Thus monetary incentives are more effective when they target vehicles that provide a tangible benefit to consumers, such as significant fuel economy improvements.

• Beresteanu and Li (2007) similarly find that federal income tax incentives, as well as gasoline prices, had a significant positive impact on HEV sales. The same study suggests that similar outcomes could be attained more cost-effectively with a rebate program.

[1] In the year 2000 the federal government started offering a $2,000 tax deduction to buyers of hybrid vehicles. The Energy Policy Act of 2005 superseded this tax deduction with a variable tax credit, the level of which depended on the fuel economy of the particular hybrid model. This credit was designed to phase out over four quarters for automakers that sold more than 60,000 hybrids.

[2] These estimates are technically valid at the margin and may vary as the market for the pertinent technology evolves. Allowing for some flexibility, the following example could help with the interpretation of this result: a credit of $1,000 would result in a 4.5percent increase in hybrid sales.

• Greene and Changzheng (2014) show that subsidy benefits reach beyond consumers receiving them. For example, they help familiarize the general public with the new technology and thus over time they reduce the magnitude of the subsidies needed to achieve similar increases in sales (all else being equal).

Contrary to expectations, Hidrue, et al. (2011) find no evidence that EV adoption is more likely among higher income or multicar households. This is a provocative finding that deserves further investigation given the interest among policymakers in the equity implications of EV policy and that earlier studies believed that EV adopters would tend to be multicar households (e.g. Kurani et al., 1996).

Additional Studies

Other studies focused on program evaluation and looked at the effect of state monetary incentives on clean vehicle sales across the United States. Sierzchula et al. (2014) examine factors that affect EV adoption, but they use multivariate regression, a methodology that does not warranty reliable results for this type of problem. Additional examples in the literature focused on HEVs. Between 2000 and 2006, eight states offered income tax credits and four states offered sales tax waivers of varying levels to hybrid buyers. Other state incentives included granting access to high-occupancy vehicle (HOV) lanes, reductions in registration fees, reductions in excise taxes, exemptions from emissions testing, and state fleet procurement requirements. Recent studies on state incentives include:

• Gallagher and Muehlegger (2011) find a significant correlation between state residents' average income and rates of hybrid adoption and simultaneously find that state tax incentives had a significant impact on consumer adoption of hybrids[3]. It should be highlighted that the effect of state average income on sales is not the same as the effect on sales of individual or household income. The latter can be measured with data at the consumer level, usually using consumer choice modeling.

• Diamond (2009) finds mixed results regarding the effectiveness of state tax incentives in supporting hybrid sales. This result may be partially due to the author's assumption that the increase in hybrid market share

[3] This suggests that both factors are at play: It cannot be inferred that the beneficiaries of the incentives are necessarily higher income groups who would have purchased these vehicles regardless of available incentives.

over time is a natural consequence of the market diffusion exhibited by new technologies[4].

Other cost factors of vehicle ownership are important. The studies above find that state average gasoline prices (or alternatively, the expected fuel cost savings offered by hybrids compared to comparable conventional cars) also play an important role in determining hybrid sales. Therefore policies that affect the price of gasoline can also affect vehicle sales— such as a carbon tax.[5]

Effective Incentives are Key

Consistent with the findings on federal incentives, state studies show that the structure of state monetary incentives can have a significant effect on a program's outcome. For example, Gallagher and Muehlegger (2011) estimate that a $1,000 income tax credit may result in a 3 percent increase in hybrid sales, while the same $1,000 offered as a sales tax waiver may result in a much larger 45 percent increase in sales.[6]

Awareness and understanding of incentives are also important factors. Krause et al. (2012) find that only 5.5 percent of respondents are aware of their state or local government's monetary incentives available to them. This result may partly be explained by the fact that this study was conducted in late 2011 when eligible products (e.g. Nissan Leaf and Chevy Volt) were still in the early stages of deployment. This finding nevertheless suggests two things: a) incentive programs may need to be much better communicated to consumers, and b) results from econometric studies (e.g. Gallagher and Muehlegger, 2008) might be underestimating the impact of incentives on the sales of advanced clean vehicles, such as HEVs and PEVs.

In summary, there is strong evidence that indicates that monetary incentives, if properly designed and communicated, are effective in supporting the early sales of advanced clean cars. The evidence currently

[4] This assumption is somewhat questionable, since market diffusion cannot be taken for granted for all new technologies. Diffusion is instead a consequence of consumer acceptance, which in turn is affected by financial considerations.
[5] Or the relative price of gasoline compared to electricity or hydrogen
[6] Several factors can help explain this large difference. Income credits are more difficult for consumers to understand and they require additional effort to claim. Additionally, the extent of the tax credit that can be claimed depends on the consumer's tax burden. In other words, consumers with higher tax burden, typically higher income households, are able to claim a higher tax benefit.

available and summarized in this memo predominantly comes from studies of HEV markets. The results are qualitatively helpful to guide PEV and FCV programs, but as the market for these technologies evolves there is an urgent need for additional consumer and economic studies, as well as continuous evaluation of existing programs in order to identify the most efficient and beneficial policies going forward.

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