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Macroeconomic effects of fiscal incentives to promote electric vehicles in Iceland: Implications for government and consumer costs

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ABSTRACT

Iceland as an island country with abundant renewable energy resources has been totally dependent on imported petroleum fuels to meet its transport fuel demand. Transition to electric vehicles (EVs) is of particular interest for Iceland as electricity can be supplied from low-cost renewable energy resources. To evaluate how the transition to EVs can be achieved through fiscal policy incentives, a dynamic simulation modelling of the integrated energy-transport system with a detailed representation of energy technologies and vehicle fleets is implemented. The model is used for a scenario analysis by incorporating key fiscal parameters including different taxes and subsidies on vehicles and fuels. The fiscal policies to induce EVs, which are applied to both vehicle usage pattern and upfront purchase cost, include petroleum fuel tax levies, vehicle tax exemption, extra fees and subsidies. Five fiscal-induced scenarios to promote EVs, including different subsidy and feebate schemes coupled with fuel tax incentives, are compared with a BAU case. The scenario analysis reveals the impact of different fiscal policy incentives on consumer decision behaviour and the implications of fiscal-induced EV promotion for vehicle ownership costs, government tax revenues/expenditure, and overall economic benefits.

1. Introduction

Transition to a green transport sector utilizing efficient powertrains and alternative fuels could significantly influence the energy sector and macro-economic systems. Besides the prospects for technological improvements, supportive measures such as fiscal incentives, fuel infrastructure provision, restriction/regulation strategies, and marketing efforts can be implemented to promote alternative fuel vehicles (AFVs). Of these factors, the fiscal incentives for fuels and vehicles, notably subsidies and tax levies, primarily affect the adoption and usage pattern of green vehicles (Brand et al., 2013; Langbroek et al., 2016).

Fiscal instruments for the uptake of AFVs, particularly electric vehicles (EVs), have been adopted in many countries (see e.g. Mock and Yang (2014) and Zhang et al. (2014) for two comprehensive worldwide comparison of fiscal incentives for the adoption of EVs). In addition, a variety of recent studies have investigated the effectiveness of alternative fiscal policy instruments to promote EVs, taking into account different perspectives such as consumer choice behaviour, greenhouse gas (GHG) mitigation, macroeconomic costs, and social benefit (for a brief review see Section 2).

The potential impact of fiscal instruments, in particular, is of great importance for small economies as they could confront major economic and social challenges in sustaining their transportation using affordable and secure resources and technological options. Iceland is an island country characterized by an isolated energy-system with abundant renewable energy resources. High dependencies on petroleum fuel imports have left Iceland vulnerable to oil price volatilities and rising GHG emissions. Transition to renewable fuels has been of particular interest for Iceland as renewable energy resources such as hydro, geothermal, and wind enable a significant and affordable potential for fuelling EV fleets. Hence, the prioritization of technological options, support measures, and fiscal policies enabling the progress towards a carbon-neutral transport is essential.

The Icelandic government has introduced incentives such as tax

Abbreviations: AFV, Alternative Fuel Vehicle; ICEV, Internal Combustion Engine Vehicle; bbl, Barrel; ISK, Icelandic Krona; BEV, Battery Electric Vehicle; km, kilometre; EV, Electric Vehicle; LDV, Light-Duty Vehicle; g, Gram; MNL, Multinomial Logit; GHG, Greenhouse Gas; PHEV, Plug-in Hybrid Electric Vehicle; HDV, Heavy-Duty Vehicle; VAT, Value Added Tax; HEV, Hybrid Electric Vehicle; $, US Dollar

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exemptions and emission-differentiated vehicle taxes to promote the contribution of green vehicles in the transport sector. Several previous energy-system studies have addressed the effects of technology development, fuel supply-push policies, banning strategies, fuel prices, and carbon tax on the evolution of AFVs in Iceland. An agent-based modelling study has predicted the market share evolution of EVs within light-duty vehicle (LDV) fleets in response to changes in gasoline price, EV purchase cost, recharging concerns, and excise duty tax (Shafiei et al., 2012). The study only addressed the competition between conventional gasoline vehicles and battery electric vehicles (BEV), assuming an exogenous representation of energy prices and fuel infrastructure. A hybrid agent-based and system-dynamics approach evaluated the interactions among consumers, vehicle market and energy supply infrastructure through a simplified case study for Iceland (Shafiei et al., 2014b, 2013). A system-dynamics model of the Icelandic energy system (UniSyD_IS) has been used to compare the potential market share of electric, hydrogen and biofuel vehicles in response to different supply-push strategies (Shafiei et al., 2015a, 2014a) as well as the cost-effectiveness of supporting renewable transport fuels (Shafiei et al., 2015b). The normative approach of Shafiei et al. (2017a) simulated the trajectories towards a carbon-neutral transport sector through stringent policies banning petroleum fuel vehicles.

The potential impacts and implications of fiscal instruments have not been thoroughly explored in Iceland in the context of energy system analysis. Fiscal policies in terms of tax and subsidy incentives can be imposed on both vehicle usage and purchase cost. These incentives help to overcome the cost disadvantage of EVs with direct short- and long-term implications for government expenses and consumer costs. To analyse the economic consequences of integrating EVs within the Icelandic transport fleet, a dynamic simulation-based analysis is performed using the system-dynamics model of Iceland's energy system (UniSyD_IS). The UniSyD_IS model enables an effective simulation of interactions among fuel supply, infrastructure expansion, market dynamics, and consumer behaviours. The main objective of this paper is to compare the macroeconomic cost responses to different fiscal incentives aimed at promoting EVs. The analysis is aimed at assessing the implications of different fiscal incentives towards electro-mobility for consumer costs and government net revenues. The main focus of the scenario simulations will be on the economic impacts of both upfront cost and vehicle usage incentives.

The rest of the paper is organized as follows. Section 2 presents a short review of recent studies focusing on the fiscal-induced promotion of EVs. In Section 3, an overview of fiscal instruments that are currently in place in Iceland are presented. The analytical tool and approach is briefly introduced in Section 4, and the main assumptions on vehicle costs are given in Section 5. The scenarios are explained in Section 6, and then the results of the model analysis are discussed in Section 7. Finally, the conclusions and policy implications are provided in Section 8.

2. Recent studies on fiscal policy analysis of EVs

The scope of the following review focuses on recent studies that have investigated the effectiveness of alternative fiscal policy instruments to promote EVs. Different studies have been classified into three main groups: the US studies, the EU studies, and the East Asian studies.

Ross Morrow et al. (2010) applied the National Energy Modelling System (NEMS) to estimate the energy, economic, and CO_2 implications of different policies from 2010 to 2030 in the US. They studied 16 vehicle technology options, including PHEVs. They concluded that purchase tax credits are ineffective in cutting emissions, while proposing an additional tax on petroleum fuels will result in the largest reductions in both CO_2 emissions and oil imports, driven by a significant reduction in annual travel distance. Having focused on the vehicle ownership cost, Tseng et al. (2013) studied five representative vehicle types (conventional, hybrid with and without plug-in, and electric), and then concluded that with federal tax incentives, all EV types driven 120,000 miles over 12 years are affordable and the additional lifetime costs compared to conventional vehicles are about 5%.

Lutsey et al. (2015) focused on the effectiveness of various promotion activities in the US cities using statistical models, considering both fiscal and non-fiscal instruments. Based on an analysis of 25 major U.S. metropolitan areas, they detected a significant variation in the effectiveness of promotion activities to advance the adoption of EVs, mainly due to the size and density of cities.

Focusing on the east Asia, the analysis by Hong et al. (2012) using a mixed logit model, indicated that annual tax incentives for EVs in South Korea are twice as effective as an initial lump-sum incentive for purchasing price as the consumer choice probability for EVs would rise by 14% due to tax incentives, compared to 7% for lump-sum incentives. Later, Hao et al. (2014) investigated the rationale of China's two-phase EV subsidy scheme and estimated their impacts on the EV market penetration, by estimating the ownership cost of BEVs. Later, Helveston et al. (2015) have used data from choice-based conjoint surveys fielded in 2012–2013 in China and the U.S. to model consumer preferences for conventional, HEV, PHEV, and BEV technologies focusing on the impacts of federal subsidies.

Shepherd et al. (2012) have used a system-dynamics approach to assess the impact of subsidies and taxation on the uptake of PHEVs and BEVs during a 40-year period in the UK. They have evaluated the effectiveness of vehicle subsidies in different scenarios. Brand et al. (2013) applied the UK Transport Carbon Model to quantify the impacts of fiscal incentives on passenger car sales and emissions until 2050 in the UK. The findings concluded that car purchase tax and feebate policies are the most effective policies in reducing life cycle GHG emissions.

In the case of Austria, Gass et al. (2014) analysed three fiscal policy scenarios; (i) upfront price support, (ii) CO_2 tax, and (iii) tax increase on fuel for ICE. They have calculated the total ownership costs for ICEV and EV from 2011 to 2020, based on the survey responses from the main automobile manufacturers and importers in Austria. The authors argued that introducing the estimated tax levels for CO_2 and fuel consumption would be less attractive compared to an upfront vehicle price support.

Market share of EV accounted for more than 22% of all new car sales in Norway in 2015 (ICCT Europe, 2016), confirming that EVs are attractive to consumers when incentives are powerful enough. Figenbaum et al. (2015) explored possible explanations to the Norwegian development considering the incentives given and the attitudes among users. They found that the current taxation scheme in Norway offers a great opportunity to influence vehicle purchase, and to compensate for marketing challenges.

Recently, Lévay et al. (2017) focused on the implications of fiscal incentives on the total cost of ownership, net price, and sales of eight EV-ICEV pairs in eight European countries using 2014 data. The collected information enlightens that exemptions from registration and annual taxes support big EVs, while initial lump-sum subsidies favour small EVs.

The presented review provides an overview of the recent studies focusing on the implication of different policies on the adoption of EVs, GHG emissions and consumer expenditures in the United States, East Asia, and Europe. The applied methodologies include system-dynamics, regression models, mixed logit model and choice-based surveys. The explored policies covered a wide range, including purchase tax credit, emissions taxes, vehicle registration fees, and tax on conventional fuels.

While many studies have focused on the impact of fiscal incentives on consumer's behaviour and vehicle ownership costs, the implications of transitions to EVs in the long-term for government revenues and overall macroeconomic benefits from both government and consumer perspectives have been less explored. The present research will provide a broader understanding of the key implications of more detailed fiscal instrument from both consumer and government aspects. For such