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Willingness-to-pay for infrastructure investments for alternative fuel vehicles

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ABSTRACT

This study investigates potential demand for infrastructure investment for alternative fuel vehicles by applying stated preference methods to a Japanese sample. The potential demand is estimated on the basis of how much people are willing to pay for alternative fuel vehicles under various refueling scenarios. Using the estimated parameters, the economic efficiency of establishing battery-exchange stations for electric vehicles is examined. The results indicate that infrastructural development of battery-exchange stations can be efficient when electric vehicle sales exceed 5.63% of all new vehicle sales. Further, we find a complementary relationship between the cruising ranges of alternative fuel vehicles and the infrastructure established.

1. Introduction

Alternative fuel vehicles (AFVs) are expected to play a role in reviving the automobile industry, as well as in mitigating carbon emissions in the transportation sector. This is reflected in the US American Recovery and Reinvestment Act of 2009 that provided tax credit for plug-in electric vehicles (EVs) and in the UK, where from 2010, purchasers were required to pay an excise duty when buying an average new gasoline vehicle (GV) while those purchased EVs in 2011 received a one-time exemption from the duty, received a rebate, and were exempt from annual vehicle taxes and showroom taxes. Similar incentives are being offered by other countries in Europe, and in 2010, Japan also began providing subsidies for EVs.

Nevertheless, the demand for AFVs is still relatively small. One of the reasons is the lack of investment in infrastructure for recharging/refueling these vehicles. The number of establishments for refueling EVs and fuel cell vehicles (FCVs) is insufficient. However, a few attempts have been made to resolve this problem. For example, London is planning to set up 1300 charging points by 2013. The "Source London" project provides a network of 400 recharge points that enable individually owned recharge equipment to be shared as of March 2012. In the US, a California-based venture company, Better Place, proposed that establishing rental battery stations, where drivers can replace a depleted battery with a fully charged battery within minutes, could serve as an effective solution. Shown evidence of consumer willingness to pay (WTP) for this sort of infrastructure, governments would be more inclined to approve investment in such infrastructure. A stated preference survey is a useful way to predict such potential demand under hypothetical scenarios in which circumstances can change dramatically.

This examines the potential demand for infrastructure investment by applying a stated preference survey conducted in Japan for hybrid electric vehicles (HEVs), EVs, and FCVs. Japan is selected as a case study because several auto manufacturers are competing to establish mass production technology for AFVs.

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Table 1
The attributes and levels of choice experiments.

Attributes		Levels			
Fuel type		GV	HEV	EV	FCV
Body type		Base 1	Base 2		
Manufacturer	GV	Base 3			
	HEV/EV/FCV	Toyota	Honda	Nissan	Mitsubishi
Cruising range (km)	GV	800			
	HEV	1000			
	EV	50	100	150	200
	FCV	300	400	500	600
Refueling rate	GV/HEV/FCV	5 min			
	EV	5 min (Exchange)	30 min	8 h	
Carbon dioxide (% reduction of a present average car)	GV	5%			
	HEV	40%	60%		
	EV/FCV	100%			
Fuel availability	GV/HEV	All existing service station			
	EV	10% of existing service stations (Exchange)	50% of existing service stations (Exchange)	Home	Home and supermarkets
	FCV	10% of existing service stations	50% of existing service stations		
Purchase price (including tax)	GV	Base 4			
	HEV	Base 4 + 20%	Base 4 + 40%	Base 4 + 60%	
	EV/FCV	Base 4 + 40%	Base 4 + 60%	Base 4 + 80%	
Annual fuel cost	GV	Base 5			
	HEV	Base 5 – 10%	Base 5 – 20%	Base 5 – 40%	
	EV/FCV	Base 5 – 20%	Base 5 – 50%	Base 5 – 80%	

Note: Base 1, Base 2, Base 3, Base 4 and Base 5 are specified by respondents respectively and differ between respondents.

2. Survey design

We select nine vehicle attributes, based on the focus of our study and the findings of previous studies. Attributes connected to refueling, refueling rate, and fuel availability are important factors that influence vehicle choice (Potoglou and Kanaroglou, 2007). Table 1 indicates these attributes and levels in detail. The characteristics of the attributes are as follows:

Fuel type: To compare the benefits of establishing infrastructure for EVs and FCVs, we considered the following four fuel types: conventional GVs, HEVs, EVs, and FCVs. Conventional GVs are treated as the base alternative that respondents were willing to purchase.

Body type: We asked respondents to choose two vehicle body types from nine alternatives that they would consider when making their next purchase decision, and used these two body type preferences to create respondent profiles. The following nine categories of vehicle body types were included in our survey: subcompact, compact/hatchback (hereafter compact), coupe, sedan, convertible, wagon, minivan, SUV/pickup truck, and truck/bus. The body types are unrelated to fuel types.

Manufacturer: We asked respondents to choose one automobile manufacturer, from a list, that they would definitely consider when making their next purchase decision, and used their preferences to create profiles for GVs. The list comprised 30 manufacturers, including foreign companies. It was assumed that only the following four representative automobile manufacturers in Japan produce HEVs, EVs, and FCVs: Toyota Motor Corporation, Honda Motor Company, Nissan Motor Company, and Mitsubishi Motors Corporation.

Cruising range: These are set as 800 km for GVs, 1000 km for HEVs, between 50 km and 200 km for EVs,[1] and between 300 km and 600 km for FCVs.

Refueling rate: The time taken to refuel all AFVs, other than EVs, is 5 min; EVs usually take longer to recharge, unless battery-exchange stations are available when the recharge time is comparable.

Carbon dioxide: By choosing an AFV, drivers can reduce the emissions of CO_2. The fuel type being used determines the CO_2 levels for all vehicles, with the exception of HEVs. Only HEVs have two levels of CO_2 emissions, and their emission levels have been reduced by 40% and 60% from the current levels.

Fuel availability: Depending on the type of FCV, either 10% or 50% of existing service stations offer the new fuel. When the battery-exchanging scenario is assumed, depending on the type of EV, either 10% or 50% of existing service stations provide

[1] The cruising range of Nissan's EV model, Leaf, is between 100 km and 220 km, depending on the speed, climate, road, and so on (Source: Nissan Leaf website: www.nissanusa.com/leaf-electric-car).