Social Welfare of the Fuel Cell Electric Vehicles and Infrastructures

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Extended Abstract

In order to respond to the global warming problem, various countries held the United Nations Conference on Environment & Development (UNCED) in 1992 and the United Nations Framework Convention on Climate Change, UNFCCC) was adopted. Subsequently, in 1997, the Kyoto Protocol, which stipulated the target of greenhouse gas reduction in developed countries, was adopted, and in 2015, the Paris Agreement on Climate Change was agreed to impose greenhouse gas reduction obligations on both developed and developing countries in place of the Kyoto Protocol, which expired in 2020.

Although international law does not impose binding force on the voluntary reduction goals submitted by each country to the Paris Agreement on Climate Change, Korea's greenhouse gas emission level is high, so efforts to reduce greenhouse gas emissions are necessary. Accordingly, the Korean government enacted the “Low-Carbon Green Growth Framework Act (Jan. 2010)” to fulfill the greenhouse gas reduction target for climate change and comply with international agreements, and the “Roadmap for achieving the national greenhouse gas reduction goal in 2020 (Jan. 2014)” ' has been prepared. This roadmap is intended to establish a detailed and effective implementation plan of the greenhouse gas reduction target of 30% compared to the 2020 Business As Usual (BAU) promised to the international community. Specifically, detailed reduction targets for 7 sectors and 25 industries were established. Among the 7 sectors, the reduction rate of the transport sector was 34.4%, the highest among the sectors. Considering that the number of registered vehicles in Korea will continue to increase in the future, the greenhouse gas emissions of the transport sector The reduction ratio is expected to become

more important.

Measures to reduce greenhouse gas emissions in the domestic transportation sector can be largely divided into the green transportation policy, which is supervised by the Ministry of Land, Infrastructure and Transport (MLIT), and manages transportation demand, the strengthening of automobile greenhouse gas emission standards promoted by the Ministry of Environment (MOE), and the expansion of the supply of eco-friendly vehicles. Considering that about 95% of the transport sector's greenhouse gas emissions are generated by roads (Greenhouse Gas Information Center, 2014), it can be assumed that policies related to automobiles, the main source of road use, will greatly contribute to reducing greenhouse gas emissions in the transport sector.

Among the policies of the MOE, in the case of strengthening automobile greenhouse gas emission standards, it is clear that emissions from vehicles such as old diesel vehicles, which are considered one of the main sources of air pollutants such as greenhouse gases, can be partially regulated. However, in the case of internal combustion vehiclesa that use fossil fuels as power sources, such as gasoline or diesel, there is a disadvantage that the greenhouse gas emitted from the vehicle cannot be reduced below a certain level. GHG emissions will also increase. On the other hand, since environment friendly vehicles, including electric vehicles and hydrogen vehicles, do not emit air pollutants while driving, unlike internal combustion engine vehicles, greenhouse gas emissions do not change even if the number of registered eco-friendly vehicles increases. The gas reduction effect becomes even greater.

Initially, the government prepared a low-carbon car cooperation fund system to expand the supply of low-carbon cars and planned to implement it from 2015, but to avoid confusion with other low-carbon systems and the burden on companies, the introduction of the system was postponed to 2021. As a supplementary measure, the government not only provided subsidies for the purchase of eco-friendly cars, but also expanded the scope of subsidies paid separately by some local governments nationwide.

Since then, due to steady public relations efforts and efforts to expand infrastructure such as charging stations, electric vehicles have recorded 134,962 units as of December 20, showing a stable market share. However, since hydrogen cars recorded 10,906 units as of the same month, they are still in the initial stage of dissemination.

This study estimated the demand function of automobile consumers and the supply function of producers and analyze the social surplus for the implementation of government policies. To estimate these functions, the assumptions and estimation models for the market structure are required.

Section 2 of this study introduces the previpou studies on the estimation of the demand function of the automobile market and summarizes the discrete selection models and their contents for the differentiated model used in the study. Also summarizes the recent research trends on environment friendly vehicles.

Section 3 describes the theoretical background and specific estimation formulas of the nested logit model used in this study among the discrete selection models. In addition, price elasticity and marginal cost matrices were derived from the coefficients estimated from the nested logit model, and a methodology for estimating the demand and supply functions was also presented. Finally, the new equilibrium price and new equilibrium obtained from the demand and supply functions The formula for finally deriving social surplus was explained by calculating consumer surplus, producer surplus, and government tax revenue based on the transaction volume.

In Section 4, the demand function and supply function of the Korean automobile market are estimated using the models and formulas presented in Chapter 3. In order to address the promotion of fuel cell electric vehicles that are needed to achieve the goal of the “Hydrogen Economy Revitalization Roadmap”, the level of government subsidy and the size of social surplus when achieving the goals of the “hydrogen economy revitalization roadmap” were estimated. The nested logit model used in the analysis is a three-stage nested logit model, and the explanatory variables used are *volume, distance, horsepower, supply, HDsupply, EDsupply, and price*. As a result of the regression analysis, the coefficients of all variables were statistically significant, and the coefficient of price was estimated to be negative, and the coefficients for size, horsepower per weight, fuel consumption per fuel, number of gas stations, number of electric vehicle chargers, and number of hydrogen charging stations were estimated to be positive. This is consistent with the behavior of real consumers, as it can be interpreted that the lower the price and the better the characteristics of a car model, such as horsepower per size or weight, the greater the utility from the model and therefore the more they purchase.

In addition, it can be seen that the criteria and classification for the groups used in this study are significant as the coefficient of $\ln s_{j|gh}$, $\ln s_{g|h}$, which is a variable representing the occupancy rate, also satisfies the relationship of $0 \le \sigma_2 \le \sigma_1 < 1$.

The own price elasticity and cross elasticity of each car model can be obtained through the coefficients estimated through the nested logit model. As a result of the calculation, the cross-elasticity between products belonging to the same group was larger than the cross-elasticity between products belonging to different groups, indicating that the realistic substitution relationship, a characteristic of the nested logit model, was correctly reflected. In addition, the comparison of self-price elasticity by model shows realistic results, such as a large difference between the absolute values of light cars and hydrogen cars and those of large and luxury cars. The price sensitivity matrix B was obtained from the price elasticity matrix estimated in this way, and finally, the demand function equation (3-35) can be derived using the known matrices Q and P.

On the supply side, assuming that the automobile market is in the form of an oligopoly, the existing market is in a state of equilibrium, and all firms are in a state in which they normally seek profits, the marginal cost of each model is derived using the profit maximization conditions of each firm. In the process, the ex-factory price for each model required in the process was estimated as the amount excluding tax from the consumer price in accordance with the tax standards of Korea. As a result of calculating the markup for each company, Hyundai Motor and Kia Motors showed the highest markup among models within the same group. In addition, electric cars and hydrogen cars recorded a much higher markup when compared to other groups, and accordingly, in the markup comparison between internal combustion locomotives and eco-friendly cars, environment friendly cars showed more than twice the markup of internal combustion vehicles.