# [*Supply Portfolio of bioethanol in the Republic of Korea*]

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## Overview

Although bioethanol contains various kinds of co-benefits such as energy security, development of relevant industry, environmental improvement, retail prices of bioethanol blended gasoline without subsidy are higher than general gasoline prices in most countries. Hence, renewable fuel standard (RFS) on petroleum industry can contribute to the development of bioethanol market in Korea. However, without controlling portions of domestic bioethanol as well as domestic feedstock for bioethanol, it is highly plausible that new bioethanol market will be filled with imported bioethnol. If the entire bioethanol is imported, Korea cannot expect those co-benefits any more. This study aims at evaluating the potential social benefits of using domestic bioethanol with domestic feedstock and simulating desirable ratios of domestic versus imported bioethanol as well as domestic feedstock versus imported feedstock. Co-benefits of domestic bioethanol was estimated by asking people's marginal willingness to pay for domestic bioethanol with a choice experiment approach and political, income, and gender heterogeneity was tested. As a result, politically neutral, female and high income groups had higher marginal willingness to pay for domestic bioethanol. On the other hand, unit production costs of bioethanol varying with different ratios between domestic and imported feedstocks was estimated by cost function approach. Combining co-benefits with the production costs, simulation was implemented to determine socially desirable ratios of domestic bioethanol with domestic feedstock. Ultimately, our study shows that about 72% of 3% bioethanol blended gasoline (E3) should be produced domestically if domestic feedstock is totally used for producing bioethanol and 64% of domestic feedstock can be used at maximum if bioethanol should be produced within Korea.

## Methods

The primary method is to measure MWTP for domestic production of bioethanol. MWTP for domestic bioethanol can be interpreted as the marginal gain from industrial and agricultural development, energy security, and environmental effects (Petrolia et al., 2010). Choice experiment approach was employed to derive Korean petroleum consumers' MWTP (Train, 2009). Different production pathways and various blending ratios for bioethanol were considered as attributes of alternative bioethanols. Political, income, and gender heterogeneity in preferences of bioethanol are investigated as well. Second method is to estimate price increase of petroleum blended with bioethanol. Average production costs of ethanol blended petroleum will be compared to the average before tax petroleum price. Production costs of domestic ethanol are estimated from panel econometric methods (fixed and random effect models, generalized least square and dynamic panel models). Difference between before tax petroleum price and 3% ethanol blended petroleum can be regarded as marginal social cost (MSC) of producing bioethanol. Combining the MWTP of domestic ethanol with the MSC, desirable portfolio of ethanol production can be derived at the point where marginal benefits of domestic bioethaonl are equal to the marginal social costs of bioethanol. Combining the two objectives, the final methodology is to simulate socially desirable portfolio of bioethanol supply. In the short run, E3 is expected to be provided under the RFS policy. About 300thousand KL of bioethanol should be provided to meet the required volume of the E3, and alcoholic beverage companies can provide 20 ~ θ% of the E3 (60thousand KL) when their supply capacity is considered at present, and about (1-θ) ~ 80% of the E3 should be imported. Meanwhile, domestic feedstock (barley) or imported one (Tapioca) can be used as materials for production of bioethanol. Korean government of agriculture ensures that there are abundant set aside of arable land that used to be used for raising barley in winter season.

## Results

Our choice experiment on supply pathways of bioethanol in the Republic of Korea showed that Korean gasoline drivers prefer domestic ethanol with domestic feedstock to imported ethanol as an appropriate supply method of bioethanol. The average MWTP for the domestic bioethanol with domestic feedstock within E10 was about 52KRW/liter which is higher than the MWTP (15~30KRW/liter) for E10 estimated in Petrolia et al.(2010). Where does this difference rise? There might be two possible interpretations: First,

the average retail petroleum price (2012) in Korea is about 2.89 times of the price (2007) in the United States1. Second, our choice experiment amphasizes use of domestic bioethanol with domestic feedstock while the study of Petrolia et al. (2010) focuses environmental gains of E10 and E85. However, according to the study of Vedenov and Wetzstein (2008) that was based on an analytic model, socially desirable subsidy on bioethanol was estimated as $0.22/gallon (54KRW/liter) which is very close to the estimate of our study. In this regard, estimated co-benefits of bioethnaol produced in Korea do not differ fundamentally from those in the United States.Korean people also prefer E5 to E3 in terms of blending ratio of bioethanol to petroleum. This finding implies that energy security and environmental improvement should be reflected as social benefit of supplying domestic bioethanol. Political, income, and gender heterogeneity on the choice of domestic bioethanol with domestic feedstock were also examined. The heterogeneity test showed that neutral group in political propensity, 2nd and 4th quantile income group, and female group prefered domestic bioethanol with domestic feedstock.The break-even combination between domestic bioethanol with 100% domestic feedstock and imported bioethanol for E3 turned out to be about 72%:28%. Also, the blending ratio of domestic feedstock can increase upto 64% under the condition that 100% of domestic bioethanol is used for E3.

## Conclusions

According to the results, entire import of bioethanol necessary for implementing conditions for the up-coming RFS regulation will not be desirable in terms of multiple criteria such as economic efficiency, environmental aspects, and energy security issues. Also, it is expected to raise uses of domestic feedstock for providing E3 even if domestic feedstock is much more expensive than imported one. Korean consumers on E3 are ready to endure increases of petroleum price in order to get co-benefits derived from domestic ethanol with domestic feedstock. Ultimately, when the Korean government implements the RFS in near future, renewable fuel certificate for domestic bioethanol with domestic feedstock should have higher credits than imported bioethanol or domestic bioethanol with imported feedstock.

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[1] Average retail petroleum price at 2012 in Korea was 1986KRW/liter, and the retail price at 2007 in the United States was $2.8/gallon.