The Green Paradox of U.S. Biofuel Subsidies: Impact on Greenhouse Gas Emissions

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Executive Summary

Although U.S. government support for biofuels is large and growing, the impact of these subsidies on greenhouse gas (GHG) emissions remains unclear. U.S. subsidies for biofuels began in the late 1970s in the form of tax credits for corn ethanol. These provisions quickly expanded to total $6.6 billion in 2010—representing over one fifth of all energy subsidies that were not related to research and development. Ethanol subsidies have especially increased rapidly over the past decade, nearly tripling over the period from 2005 to 2009. As the subsidies have grown, so has biofuel production—from nearly zero in 1978 to over 10.5 billion gallons in 2009.

Federal subsidies for biofuels have been justified, in part, by the expectations that the increased use of biofuels would mitigate GHG emissions. Yet, the impact of federal support for biofuel production and consumption remains unclear. This article evaluates the effect of major federal programs that support U.S. biofuel production and consumption.

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Biofuels can either increase or decrease carbon emissions, depending on a fuel's GHG emissions and relevant elasticities of supply and demand. Even when a biofuel has lower GHG emissions than the conventional fuel it is intended to replace, a subsidy could result in a "green paradox," when a policy intended to achieve environmental goals actually exacerbates the problem. A subsidy for a biofuel can increase total fuel use, and possibly total GHG emissions, even when the biofuel has lower lifecycle GHG emissions than the conventional fuel it displaces. This is because a biofuel subsidy results in two major effects—a substitution effect and a price effect.

The substitution effect is well known in the literature and by policymakers. The effect causes biofuel to displace conventional fuel and thus reduces consumption of fossil fuel as well as GHG emissions. The other effect, a price effect, lowers the overall market price of the blended fuel, which increases total fuel consumption and therefore GHG emissions. Whichever of these countervailing effects dominates determines whether total GHG emissions are reduced or increased. Surprisingly, the price effect is not accounted for by U.S. regulators when evaluating the impacts of biofuel policy. Not accounting for this effect has large implications, given that nearly all gasoline sold in the United States contains biofuel. If the price effect is large enough, then federal support for biofuels could result in a green paradox.

This paper presents the first comprehensive estimates of the impact of U.S. biofuel subsidies on greenhouse gas emissions. To evaluate national-level subsidies from 2005 to 2009, we develop an economic simulation model of U.S. energy markets. The model's coverage generally follows the approach taken by the U.S. Energy Information Administration (EIA) in constructing the National Energy Modeling System (NEMS). The model uses supply and demand relationships to represent the production and end-use consumption of oil, natural gas,

coal and electricity in four sectors (residential, commercial, industrial and transportation) with additional detail in the transportation sector and the production of biofuels.

We calibrated the model so that the prevailing U.S. energy market conditions for each year from 2005 through 2009 with all the subsidies in place are considered business as usual. The effects of each subsidy are quantified through a counterfactual evaluation of how the market would have looked in the absence of the particular subsidy being examined. For each subsidy, the effect on market prices and quantities is determined by subtracting the per unit subsidy at the existing market price and quantity and generated a new supply curve for the biofuel in question. We then used the altered supply curve to determine what energy-market prices and quantities would have prevailed for all energy sources in the absence of the subsidy. The changes in market quantities are the basis for calculating the changes in GHG emissions.

The relative magnitude of the countervailing substitution effect and price effect depend on the relative GHG emissions of the biofuel and conventional fuel as well as elasticities of supply and demand. For sensitivity analysis, best and worst case scenarios were developed to assess the extent to which GHG emissions estimates are affected by key assumptions. These key assumptions included demand elasticities of fuels and relative GHG emissions of biofuels and fossil fuels.

We find the total net effect of U.S. government support for biofuels over the study period 2005-2009 was to increase total GHG emissions in the United States by over three million metric tons. Subsidies for ethanol increased greenhouse gas emissions, while those for biodiesel have an ambiguous effect. Thus, ethanol subsidies appear to create a green paradox. Although ethanol has lower lifecycle greenhouse gas emissions than unblended gasoline, the subsidies lower the market price of blended fuel, which increases overall fuel consumption and increases

total greenhouse gas emissions. The green paradox of ethanol subsidies is a particularly important finding because government support for alternative fuels is partially justified by goals to mitigate greenhouse gases.

Subsidies for biodiesel also might yield a paradox, if GHG emissions from biodiesel are not sufficiently lower than conventional diesel. However, even when subsidies for biodiesel result in GHG reductions, this approach to carbon mitigation can be costly. For example, one major biodiesel provision achieves GHG emissions reductions at a cost of about $848 per metric ton of CO_2e (in 2009$).

These findings question the suitability of using biofuel subsidies to achieve climate goals and highlight the importance of accounting for the price effects of biofuel policies. Policymakers who subsidize alternative fuels with the idea of reducing GHG emissions need to look closely at the lifecycle emissions associated with the fuels and the probable market response. Our analysis highlights the importance of accounting for the price effect of biofuel policies. If biofuel policies are to be justified by GHG mitigation, then regulatory assessments must account for the price effect of biofuel policies. By not considering the price effect, federal programs might support policies that result in a green paradox.