Journal of Environmental Economics and Management 67 (2014) 241–257

Contents lists available at ScienceDirect

Journal of
Environmental Economics and Management

journal homepage: www.elsevier.com/locate/jeem

Alternative transportation fuel standards: Welfare effects and climate benefits☆

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ARTICLE INFO

Article history:
Received 25 July 2011
Available online 20 January 2014

Keywords:
Biofuel mandate
Low Carbon Fuel Standard
Greenhouse gas emissions
Social welfare
Corn ethanol
Cellulosic biofuels
Dynamic optimization
Sectoral model

ABSTRACT

This paper develops an integrated model of the fuel and agricultural sectors to analyze the welfare and greenhouse gas emission (GHG) effects of the existing Renewable Fuel Standard (RFS), a Low Carbon Fuel Standard (LCFS) and a carbon price policy. The conceptual framework shows that these policies differ in the incentives they create for the consumption and mix of different types of biofuels and in their effects on food and fuel prices and GHG emissions. We also simulate the welfare and GHG effects of these three policies which are normalized to achieve the same level of US GHG emissions. By promoting greater production of food-crop based biofuels, the RFS is found to lead to a larger reduction in fossil fuel use but also a larger increase in food prices and a smaller reduction in global GHG emissions compared to the LCFS and carbon tax. All three policies increase US social welfare compared to a no-biofuel baseline scenario due to improved terms-of-trade, even when environmental benefits are excluded; global social welfare increases with a carbon tax but decreases with the RFS and LCFS due to the efficiency costs imposed by these policies, even after including the benefits of mitigating GHG emissions.

Introduction

Concerns about greenhouse gas (GHG) emissions and the desire to reduce dependence on foreign oil have led to support for policy strategies targeted directly at promoting low carbon biofuels in the United States (US) (DOT, 2010). While renewable fuels for transportation are currently limited to first-generation biofuels produced primarily from corn in the US and sugarcane in Brazil, there is growing emphasis on inducing a shift to a new generation of advanced biofuels. Unlike first-generation biofuels, second-generation biofuels can potentially be produced from a variety of feedstocks, such as crop and forest residues and dedicated energy crops, like miscanthus and switchgrass. While advanced biofuels are yet to be produced commercially, studies indicate that high-yielding energy crops can be grown productively on low quality land and that these biofuels have significantly lower (even negative) GHG intensity than fossil fuels and first-generation biofuels (Gelfand et al., 2013; Tilman et al., 2009).

☆ Authorship is alphabetical. Funding from the Energy Biosciences Institute, University of California, Berkeley, from NIFA/USDA, and from the Energy Foundation, National Low Carbon Fuel Standard Project, is gratefully acknowledged.
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http://dx.doi.org/10.1016/j.jeem.2013.09.006

Policies to induce biofuel production in the US include technology (biofuel) mandates and performance-based standards for transportation fuel. The former has taken the form of the Renewable Fuel Standard (RFS) established by the Energy Independence and Security Act (EISA) of 2007, which sets annual volumetric (quantity-based) targets for the blending of specific types of biofuels with fossil fuels based on their life-cycle GHG intensity. A Low Carbon Fuel Standard (LCFS) is a performance-based standard to reduce the GHG intensity of transportation fuel. A national LCFS to reduce GHG intensity of transportation fuel by 10% by 2020 was among the early proposals for promoting low carbon fuels in the US in 2008.[1] In contrast to these policies, a carbon price policy could be used to directly target a reduction in GHG emissions.

By explicitly or implicitly imposing taxes or providing subsides, these policies affect the relative prices of various biofuels and fossil fuels. With the potential to produce different types of first- and second-generation biofuels that differ in their land requirements, GHG intensity and costs of production, these policies will differ in the extent to which they induce biofuel consumption and in the mix of biofuels induced. These policies will, therefore, vary in the extent to which they will divert land from food/feed production and adversely affect crop prices.

The volume and mix of biofuels will also directly affect the extent to which fossil fuels are displaced and the GHG intensity of the resulting fuel mix. Additionally, biofuels will affect GHG emissions indirectly by affecting food and fuel prices.[2] Increased food prices could lead to indirect land use change (ILUC) that occurs as cropland expands and releases stored carbon in soils and vegetation globally; this leakage effect will affect the net GHG savings achieved by inducing more biofuel production. The magnitude of the ILUC effect will vary with the quantity and mix of biofuels and, thus, across policies; cellulosic biofuels produced from crop residues or energy grasses grown on less productive/marginal land will have a smaller impact on food crop prices than food crop-based biofuels. Moreover, by lowering the demand for fossil fuels in the US these policies have the potential to decrease the price of fuel in the world market. This could lead to a rebound in fossil fuel consumption in the US and the rest of the world (ROW), such that biofuels displace less than the energy equivalent amount of fossil fuels and offset a part of the GHG savings with biofuels.

This paper develops an integrated model of the fuel and food sectors to compare these effects of a biofuel mandate, a LCFS and a carbon tax on the mix of biofuels and fossil fuels, land use changes, and on food and fuel prices. We first present a simple conceptual framework to analyze the differential mechanisms by which these policies affect food and fuel consumption and GHG emissions and identify some of the key parameters in the food and fuel sectors likely to influence these outcomes. We then quantify these effects over the 2007–2030 period using a partial equilibrium, open economy, dynamic model of the fuel and agricultural sectors of the US (Biofuel and Environmental Policy Analysis Model (BEPAM)). We select the GHG intensity reduction targets for the LCFS and the carbon tax rate to achieve the same level of US GHG emissions as the RFS over the 2007–2030 period to obtain comparable outcomes under these three policies. Even though their impact on domestic GHG emissions are normalized to be the same, these policies can differ in their impact on global emissions because of the differences in their impact on global food and fuel prices, and thus on fuel consumption by the ROW and on the international ILUC.

Furthermore, we compare the welfare effects of these three policies both for the US and for the ROW. By inducing consumption of high cost biofuels beyond the free market level, these policies impose efficiency costs on the domestic food and fuel sectors. In a closed economy, these policies will impose a net economic cost, relative to a no-policy (*laissez-faire*) scenario, with the carbon tax inducing the lowest-cost mix of GHG abatement strategies unlike a mandate and GHG intensity standard that limit the flexibility of abatement options. However, in an open economy, these policies could improve the terms-of-trade for the US to varying degrees depending on the extent to which they raise the prices of agricultural exports and lower the price of fuel imports. This would shift a part of the costs of biofuel policies to trading partners (causing them to be referred to as "*beggar-thy-neighbor*" policies) (Böhringer and Rutherford, 2002), thereby offsetting their efficiency costs relative to the no-policy scenario (Moschini et al., 2010). These policies could therefore lead to positive net economic benefits in the US (even without including their environmental benefits), however their magnitudes need to be compared empirically after incorporating the potential for the efficiency costs to decline over time with improvements in the industrial costs of producing advanced biofuels and growth in biofuel feedstock yields (Chen et al., 2012). Moreover, these biofuel and climate policies implemented in the US could have different impacts on the ROW. We examine the distributional effects of these policies on food and fuel consumers and producers both in the US and the ROW. We consider the potential for cost reducing technological change in biofuel production due to learning-by-doing and its implications for the welfare costs of alternative policies. Lastly, we consider the possibility that the LCFS and carbon tax policy could coexist with the RFS and compare the welfare and GHG effects of implementing these policies together to those with the RFS alone.

Several studies have used stylized models of the fuel sector to analyze the effects of policies to induce the production of corn ethanol on GHG emissions. de Gorter and Just (2009) and de Gorter and Just (2008) analyze the effects of various policies such as a biofuel mandate, tax credit and import tariffs on fuel prices while Khanna et al. (2008) compare the effects of a mandate and tax credit on GHG emissions. Rajagopal et al. (2011), Drabik and de Gorter (2011), and Thompson et al.

[1] http://usliberals.about.com/od/environmentalconcerns/a/ObamaEnergy_2.htm. Since then, a state-wide LCFS has been established in California, which requires a 10% reduction in the GHG intensity of transportation fuels sold in the state by 2020. Many other states have also proposed regional or state-level LCFS and a proposal for a national LCFS was also included initially in the proposed American Clean Energy Security Act in 2009.

[2] Holland (2012) discusses the optimal selection of emissions taxes and intensity standards with and without leakage, and show that in the presence of emissions leakage an intensity standard can dominate the optimal emissions taxes.