Energy Economics 62 (2017) 291–301

Contents lists available at ScienceDirect

Energy Economics

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

Welfare implications of the renewable fuel standard with an integrated tax-subsidy policy

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ARTICLE INFO

Article history:
Received 29 March 2016
Received in revised form 11 November 2016
Accepted 6 January 2017
Available online 22 January 2017

JEL classification:
H23
Q48
Q16
Q43

Keywords:
Renewable fuel standard
Carbon tax
Revenue-neutral

ABSTRACT

This paper derives the optimal integrated tax-subsidy policy where one input is taxed and revenues are used to subsidize the use of a substitute input to reduce greenhouse gas emissions given the existing policies under the Renewable Fuel Standard policies. We measure the welfare effects and impact on cellulosic ethanol production after implementing the tax-subsidy policy using a general equilibrium model. A revenue-neutral integrated tax-subsidy scheme leads to a small positive tax rate for crude oil and a large positive subsidy for cellulosic ethanol because the former has a larger emissions coefficient than the latter. The overall welfare effects of an integrated tax subsidy scheme are less than a 1% increase for the economy but the growth in the cellulosic ethanol industry could range from 28% to 238% because the revenues from taxing crude oil are directly used to subsidize cellulosic ethanol production.

1. Introduction

A carbon tax is one of the programs considered and developed to reduce greenhouse gas (GHG) emissions. Several countries have implemented national carbon taxes such as Denmark (IEA, 2002), Sweden (Hammar and Jagers, 2007), Finland (Vourc'h and Jimenez, 2000) and parts of Canada (British Columbia Ministry of Small Business and Revenue, 2008). Carbon taxes are touted by economists as an effective instrument in addressing climate change (Tol, 2005). However, political concerns hindered significant traction at the federal level in the United States (Metcalf, 2009).

When the revenue from a carbon tax is used to offset an existing distortionary tax policy or it is used to subsidize relatively cleaner technology, public support for carbon taxes across political groups increase drastically (Amdur et al., 2014). Feebates are an example of a pollution tax where the revenues are used to subsidize the use of less polluting or clean good. In the energy market in Gainesville, Florida, a surcharge on consumption of electricity is collected and the ensuing revenues are used to fund the purchase of electricity generated by privately owned solar panels (New York Times, 2009). In the automotive market, taxes are imposed on low mileage cars and a tax rebate is imposed on high mileage cars (Greene et al., 2005). Such policies shift consumption toward goods that are relatively less polluting (Johnson, 2006).

The US government enacted the Energy Independence and Security Act (EISA) of 2007 as an attempt to reduce fossil fuel dependence by increasing renewable fuel and as a way to reduce GHG emissions by substituting for feedstock that has a relatively lower emissions coefficient. The law provides incentives to increase conventional biofuel production from feedstocks such as sugar or starch as well as advanced biofuels using cellulosic feedstocks such as woody crops or agricultural residue. EISA mandates an increasing role for cellulosic biofuel use such that by 2022, 16 billion gallons are required to be used which is larger than the 15-billion-gallon consumption mandate for conventional biofuel (GPO, 2011).

Even with a growing emphasis on cellulosic biofuels relative to conventional biofuels, the production of the cellulosic biofuel is slow. Only 20,069 gal of cellulosic biofuel were produced in 2012, despite an original mandate of 0.5 billion gallons (EPA, 2013). There are two relevant Renewable Fuel Standard (RFS) policies related to the cellulosic biofuel requirement: the input ratio requirement which imposes a lower bound on the amount of cellulosic fuel used in production and the price of waivers which can be used to circumvent the input requirement (Skolrud et al., 2016). Given the political feasibility of pollution taxes where the revenues subsidize less polluting substitute goods, an

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http://dx.doi.org/10.1016/j.eneco.2017.01.008
0140-9883/

interesting question arises: How will such a tax-subsidy system affect welfare in the presence of the existing RFS policies that incentivize cellulosic fuel production?

The objective of this article is to determine the effect on welfare and cellulosic fuel production from an integrated tax-subsidy policy that reduces GHG emissions given the existing RFS policies related to the cellulosic biofuel requirements. We develop a general equilibrium model of GHG based subsidies for low carbon emitting energy inputs such as cellulosic fuel that are funded solely by taxes on high energy carbon emitting sources such as crude oil. This approach alleviates concerns regarding implementation of taxes only or subsidies only since the policy can be revenue-neutral where aggregate additional tax revenues is zero and no new expenditures are added.

We contribute to the literature in two ways. First, this is the first paper that solves for the optimal integrated tax-subsidy policy in a general equilibrium framework. Galinato and Yoder (2010) developed a partial equilibrium framework that analyzed the optimal derivation of taxes and subsidies across various energy output sources. We extend their model by using a general equilibrium framework with multiple sectors and incorporating the integrated tax-subsidy framework in the use of inputs that are blended in the production of fuel. Second, by incorporating the integrated tax-subsidy framework on top of the current RFS policies, we are able to determine the extent to which the integrated tax-subsidy policy can boost cellulosic biofuel production. We calibrate and simulate the model for Washington State, Idaho and Oregon – states with varying abundance of cellulosic feedstock in the form of woody biomass (Yoder et al., 2010).

In a partial equilibrium framework, the standard Pigouvian tax rate is equal to marginal damages created by the pollutant and independent of emissions from other sectors in the economy (Sandmo, 1975; Kopczuk, 2003). Galinato and Yoder (2010) was the first paper to model the feebate structures by formally deriving the optimal output tax-subsidy schedules from an optimization model. They show that output taxes and subsidies across sectors are not separable because the magnitude and sign of a tax on one form of energy depends in part on the relative emissions of the other energy sources. We extend the analysis by determining the effect on the input mix when the integrated tax subsidy framework is used to incentivize use of a relatively cleaner input (cellulosic fuel) to produce blended fuel rather than a more polluting source (crude oil). Also, unlike Galinato and Yoder (2010), we solve the integrated tax-subsidy schedule using a general equilibrium framework as opposed to a partial equilibrium model to capture any potential spillover effects from other sectors in the production chain.

The integrated tax-subsidy framework has some similarities to the double-dividend literature where pollution taxes are imposed on dirty goods and revenues are used to reduce the rate of a pre-existing distortionary tax such as an income tax (Parry, 1998), but there are key differences. First, the double-dividend literature usually uses labor as a revenue source and a destination for subsidies but in our case, labor only plays an indirect role because the tax and subsidized inputs are all in one sector of the economy. Second, the double-dividend literature does not solve any optimal subsidy level for the pre-existing distortionary tax since the market is usually assumed to not have any externalities related to it. In our case, not only do we solve for the optimal tax on the polluting input, but we also solve for the optimal subsidy of a cleaner input because it may be possible that the cleaner input yields pollution albeit at a lower level than the dirtier input.

The renewable fuel mandate set by the EPA is an input pollution standard. The input pollution standard is second only to output standards in curbing total production of a dirty firm (Helfand, 1991). The standard is imposed as an input ratio mandate, which requires cellulosic biofuel to be used in production equal to a percentage of the nonrenewable fuel used in production. In 2014 this percentage was set at approximately 0.02%, rising to 0.128% by 2016 (EPA, 2016).[1] When cellulosic production is insufficient, fuel producers can buy waiver credits to satisfy their cellulosic RFS obligation (GPO, 2011). Purchasing one waiver credit is equivalent to using a gallon of cellulosic biofuel, and is priced at the greater of $.25 and $3.00 minus the wholesale price of gasoline (GPO, 2011). These two instruments together have led to low cellulosic production even when the input-ratio requirement is raised because firms have the option to purchase waivers instead (Skolrud et al., 2016). Skolrud and Galinato (2015) integrate a revenue-neutral tax into a general equilibrium framework where crude oil use is taxed and the revenues are used to reduce a sales tax in Washington and an income tax in Oregon. However, they do not consider incentivizing adoption of alternative inputs in fuel blending such as subsidizing cellulosic ethanol production.

We modify the general equilibrium model developed by Skolrud et al. (2016) to solve for the optimal tax-subsidy mechanism in the presence of the RFS policy. Our theoretical model shows that when a constraint on tax revenues are implemented, the marginal welfare from the targeted tax is introduced in the optimal conditions creating a smaller tax rate for crude oil and a subsidy for cellulosic fuel. Numerical simulations indicate that the imposition of such a mechanism would be welfare improving in Washington. In the unconstrained tax revenue case, we find that the tax on crude oil ranges between $0.35/gal and $0.74/gal, while the optimal tax on cellulosic biofuel ranges from $0.12/gal to $0.51/gal. The optimal unconstrained tax rates are larger than the Pigouvian level to account for additional distortions due to input substitution, imperfect competition and the existence of waiver credits. When a targeted net tax revenue of zero is imposed, the crude oil tax shrinks significantly, ranging from $0.00006/gal to $0.0005/gal, while the tax on cellulosic biofuel turns to a subsidy, which ranges from $0.41/gal to $1.28/gal. The disparity in magnitude and sign between the taxes is due to the lower emission coefficient of cellulosic biofuel compared to crude oil and the low input ratio between cellulosic biofuel and crude oil. If such an integrated tax-subsidy policy is implemented, cellulosic biofuel usage increases by 28% to 238% but overall social welfare increases by less than 1%. While our model is calibrated and simulated for three states in the Pacific Northwest, we provide additional simulations that generalize our results for other regions with varying endowments of cellulosic ethanol feedstocks.

2. Model

Our general equilibrium model has six sectors which include two feedstock sectors, a cellulosic refining sector, a blended fuel sector, a composite good sector, and a consumer sector. The output from the two feedstock sectors, the agricultural and forest sectors, can either be used as inputs for the production of cellulosic biofuel in the cellulosic refining sector or used by the composite good sector to produce a final good.[2] The blended fuel sector, in turn, purchases the cellulosic ethanol along with crude oil to produce blended fuel while facing the input ratio mandate and waiver credit policies in the RFS. Finally, consumers purchase fuel and a composite consumption good. Production of blended fuel emits pollution which is harmful to the consumer. The government corrects this externality using a revenue-neutral, integrated tax-subsidy policy that taxes the dirty input and subsidizes the clean input. Fig. 1 summarizes the relationship between sectors in the model and highlights the various interdependencies between the sectors of the model.

[1] These percentages have been adjusted downwards by the EPA to account for limited cellulosic biofuel production (EPA, 2016). In 2016, the percentage standard specified by the RFS legislation was set at approximately 2.6%, rising to over 9% by 2022. A 9% standard at current fuel consumption is equivalent to approximately 16 billion gallons of cellulosic biofuel (GPO, 2011).

[2] While cellulosic feedstock can be refined into different types of biofuel, refiners have focused on cellulosic ethanol in particular, which is reflected in our theoretical and numerical analysis.