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The interaction between EU biofuel policy and first- and second-generation biodiesel production

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ABSTRACT

We build a tractable partial equilibrium model to study the interactions between the EU biofuel policies (mandate and double-counting of second-generation biofuels) and first- and second-generation biodiesel production. We find that increasing the biodiesel mandate results in a higher share of first-generation biodiesel in total diesel fuel, but leads to a lower share of second-generation biodiesel. The double-counting policy supports the production of second-generation biodiesel at the expense of a lower share of first-generation biodiesel, and increases the consumption of fossil diesel as compared to treating first- and second-generation biodiesel equally. Finally, improved collection of used cooking oil reduces the price of oilseeds and oils thereof, the prices of both biofuel types, and negligibly also the consumer fuel price.

1. Introduction

Liquid biofuels accounted for about 4% of total fuel use in the EU transport sector in the period 2009–2013 (Eurostat, 2015). Of all biofuels consumed in the European Union, biodiesel was the most important, taking a 75-% share; (Klessmann et al., 2011; Eurostat, 2015) hence, our focus on biodiesel.

Driven by concerns related to the impacts of first-generation biofuels[1] on the environment and food commodity prices, the European Parliament voted in 2013 in favor of a partial switchover to second-generation biofuels (EP Press Release, 2012). Second-generation (advanced) biofuels are produced from lignocellulosic biomass (e.g., corn stover, wood chips, or used cooking oil) or animal materials (e.g., animal fat) that do not compete with food production directly. This switchover meant that a 7-% cap was put in place on first-generation biofuels (Biofuels Digest, 2014). The overall 10-% target for 2020 was not changed, however.

The EU legislation provides an incentive to Member States to use more advanced biofuels by counting the consumed energy of second-generation biofuels twice as much toward the mandate as the energy derived from first-generation biofuels—so called double-counting. The European Commission does not provide a uniform measure to implement the double-counting; instead, Member States can choose ways of implementing it (Pelkmans et al., 2014). The two most used methods are substitution obligations and tax reductions. Substitution obligations require a certain share of biofuels in transport fuels, with some biofuels counted twice to reach this target. Tax reductions mean reduced taxes for biofuels over fossil fuels with differentiated taxes (in some cases) for biofuels eligible for double-counting.

The objective of this paper is to investigate the market (i.e., price and quantity) effects of the interaction between EU biofuel policy and first- and second-generation biodiesel production. In doing so, we document several interesting and paradoxical outcomes. For example, a higher biodiesel mandate results in a higher share of first-generation biodiesel in total diesel fuel, but the share of second-generation biodiesel declines. The double-counting pol-

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[1] First-generation biofuels are produced from commodities that are also used in food production, such as corn, sugarcane, or rapeseed.

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icy supports the production of second-generation biodiesel at the expense of a lower share of first-generation biodiesel, and increases the consumption of fossil diesel compared to treating first- and second-generation biodiesel equally. Last, but not least, improved collection of used cooking oil reduces the price of oilseeds and oils thereof, the prices of both biofuel types, and negligibly also the consumer fuel price.

The contribution of our paper to the existing modeling efforts—summarized, for example in Janda et al. (2012)—is in building a traceable economic model that is able to capture the most important features of the key EU biofuel policies and their interactions with first- and second-generation biodiesel production.[2] By clearly identifying the channels through which the policies have an effect on the related markets, we complement previous modeling efforts that analyze the effects of using agricultural residues for bioenergy production on the global land use change and food security (e.g., Smeets et al., 2015).

2. Model of the EU biodiesel market

Biodiesel derived from oilseeds (and oil palm) is produced through a two-stage process. Oilseeds are first crushed to yield oil and meal. Biodiesel is then produced from the oil in a second stage. The two-stage biodiesel production process and the jointness in oilseed crushing (i.e., oil and meal) weaken the link between biodiesel and its feedstock prices as compared to the relationship between corn and ethanol prices where ethanol is produced directly from corn (Drabik et al., 2014; de Gorter et al., 2015).

Our model considers three markets: the feedstock market, the biodiesel market, and the fuel market. We include first- and second-generation biodiesel. Consumers demand kilometers traveled derived from the fuel blend (i.e., the blend of biodiesel and diesel). For internal consistency of the model, we convert all prices and quantities related to the fuel market into diesel energy-equivalent liters (DEELs); however, to ease the interpretation of the results, the model outcomes are later presented in volumetric terms.

2.1. Feedstock market

We consider three types of feedstock for the production and consumption of first-generation biodiesel: rapeseed, other oilseeds (an aggregate of all other oilseeds used in the European Union), and palm oil.[3] The choice of these three feedstocks is based on their importance in biodiesel production, with rapeseed accounting for more than half of the production and palm oil and all other oilseeds taking an almost equal share (IISD, 2013). We do not consider palm kernel meal, the byproduct of crushing oil palm seeds, as the crushing takes place outside the European Union and only palm oil is imported.

We assume competitive processors of oilseeds to earn zero marginal profits in the long-run. If this assumption were not the case, processors would bid up feedstock prices, driving profits to zero. Because oil and meal from rapeseed are produced in fixed proportions, the revenue per metric tonne of rapeseed is given by the share of oil (β_1) times the market price of oil (P_O) plus the share of meal (β_2) times the price of meal (P_M). The total cost related to rapeseed crushing consists of the cost of the feedstock (P_R) and the processing cost (C_0^R) (e.g., electricity and labor). The zero-profit condition for rapeseed crushing is therefore

$$\beta_1 P_O + \beta_2 P_M - P_R - C_0^R = 0 \tag{1}$$

Similarly, for other oilseeds (denoted by a superscript A), we have

$$\beta_1^A P_O + \beta_2^A P_M - P_A - C_0^A = 0 \tag{2}$$

In Eq. (2), we allow for different oil and meal yield parameters as well as processing costs. We assume that rapeseed oil and other oils are close substitutes in biodiesel and non-biodiesel use, hence the use of a single oil price. Meals are also assumed to be close substitutes in animal feed consumption. Acknowledging that our assumptions do not perfectly correlate with reality, we note, however, that they do not affect our qualitative results but help to streamline the intuition.

Biodiesel is produced by competitive producers. One metric tonne of oil yields β_3DEELs of first-generation biodiesel. Denoting the price of first-generation biodiesel per DEEL as P_B^I and the processing cost per DEEL of biodiesel as C_0^{BI}, the zero-profit condition for biodiesel production then links the oil and first-generation biodiesel prices through

$$P_O = \beta_3 \left(P_B^I - C_0^{BI}\right) \tag{3}$$

The price of palm oil (P_{PO}) has historically been below the price of oilseed oils. We therefore model it as a percentage (δ) of the oilseed oil price, where the coefficient δ is empirically estimated from historical data

$$P_{PO} = \delta P_O \tag{4}$$

The total supply of rapeseed (S_R) and other oilseeds (S_A) in the European Union consists of the domestic supply S_R^{EU} and S_A^{EU}, respectively, as well as of the corresponding net trade, N_R $N_A$and

We define net trade as the difference between exports and imports. The domestic supply curves and the net trade curves depend on the price of commodities they represent, hence, we have

$$S_R = S_R^{EU}(P_R) - N_R(P_R) \tag{5}$$

$$S_A = S_A^{EU}(P_A) - N_A(P_A) \tag{6}$$

The market-clearing condition for meal requires that the total meal demand (left-hand side of Eq. (7)) be equal to the domestic meal supply, adjusted for net trade (N_M)

$$D_M(P_M) = \beta_2 S_R + \beta_2^A S_A - N_M(P_M) \tag{7}$$

2.2. Biodiesel market

First-generation biodiesel is produced from rapeseed, other oilseeds, and palm oil in our model. The oil from these feedstocks is not only used for biodiesel production, but also for non-biodiesel use, for simplicity referred to as human consumption (recognizing, however, that non-biodiesel use also includes industrial use of oils). Therefore, in equilibrium, the demand for human consumption of oil (D_O^{NB}) is equal to the total supply of oil adjusted for net trade in oil, less the quantity of oil corresponding to first-generation biodiesel production

$$D_O^{NB}(P_O) = \beta_1 S_R + \beta_1^A S_A + S_{PO}(P_{PO}) - N_{RO}(P_O) - N_{AO}(P_O) - \frac{S_B^I}{\beta_3}, \tag{8}$$

where $S_{PO}(P_{PO})$ denotes the import supply curve of palm oil facing the European Union; $N_{RO}(P_O)$ and $N_{AO}(P_O)$ denote the net trade curves for rapeseed and other oilseeds oil; and S_B^I denotes the quantity of domestic EU first-generation biodiesel production. The term S_B^I/β_3converts the biodiesel quantity into its oil equivalent.

Virtually all second-generation biodiesel in Europe is currently produced from used vegetable cooking oil (UCO) and animal fats.

[2] Detailed computable general equilibrium or partial equilibrium models are useful for policymaking purposes, but have mostly not been designed to analyze the effects of biofuel policies.

[3] We use soybean and sunflower seed as other oilseeds as the share of the remaining oilseeds (e.g., linseed) is negligible (IISD, 2013).

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