Global Food Security 2 (2013) 89–96

Contents lists available at SciVerse ScienceDirect

Global Food Security

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

Second generation biofuels and food crops: Co-products or competitors?

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ARTICLE INFO

Article history:
Received 7 September 2012
Accepted 19 March 2013

Keywords:
Second generation biofuel
Food security
Food versus fuel
RFS

ABSTRACT

Stylized experiments of an economic model show that second generation biofuels can hurt or help food security. Impacts depend critically on whether the feedstock competes with traditional crops or is a co-product in their production. Dedicated biomass, like warm season grasses, likely competes at least somewhat with food crop production. To the extent that agricultural land is allocated to dedicated biomass, food prices will increase. Biofuel from crop residues, such as corn stover and wheat straw, can lead to more land in these uses, potentially reducing food and feed prices. Second generation biofuel impacts also depend on policy mechanisms and market context. For example, the US biofuel mandates that encourage new biofuels might limit their ability to displace other biofuels.

1. Introduction

The food versus fuel debate based on current biofuel feedstocks might not be directly relevant if future biofuels are made from biomass that is not used for food. In the popular press, this debate was based on the premise that biofuels, particularly US ethanol made from corn starch, competes with food uses of agricultural sector output and consequently drives up prices and reduces food security. Scientific assessment of the factors driving the price spike of 2005–2007 includes biofuels among a long list of factors (Abbott et al., 2008, 2009; Dewbre et al., 2008; EC, 2008; International Food Policy Research Institute (IFPRI), (2007); Meyers and Meyer, 2008; OECD-FAO, 2008, 2010; USDA ERS, 2008; Westhoff, 2010; World Bank, 2008). A key uncertainty is how second generation biofuels made from new feedstocks will affect food prices. Whereas corn starch and sugar cane used to make ethanol could instead be used for food, new biofuel feedstocks such as biomass from warm season grasses or agricultural residues do not directly detract from food uses or are co-products in food commodity production.

The main instrument of current US biofuel policy is the Renewable Fuel Standard (RFS) that sets minimum biofuel use mandates (Public Law (P.L.) 110–140, 2007; US EPA, 2010a). There are four components of the mandate, each with its own criteria relating to greenhouse gas emission targets, conversion process, and eligible feedstocks. These mandated levels rise in the future, with growing emphasis on biofuels made using new processes and as-yet little used feedstocks. The volume of corn starch ethanol eligible for the mandate hits a plateau of 15 billion gallons (b.g.) in 2015 and the biodiesel mandate must be at least 1 b.g. after 2012. The mandate for cellulosic and agricultural waste based biofuels (or, more simply, "cellulosic mandate") begins at 0.1 b.g. in 2010 and rises to 16 b.g. in 2022.

Actual production and use of cellulosic biofuels have been below the targets up until now, and future production technology development is uncertain. The Environmental Protection Agency (EPA) has waived this part of the mandate each year so far because projected production potential has fallen well short of the target volume. Data provided by the EPA that track compliance certificates suggest that no cellulosic biofuel was used before 2012 and about 0.00002 b.g. (20,000 gallons) were used in 2012. After assessing projected volumes that could be made in 2013, the EPA waived the cellulosic mandate from 1 b.g. initially set by law to 0.014 b.g. Nevertheless, cellulosic biofuel has been a target of policy, including special treatment even with the mandate waived and a special production tax credit. Pilot projects exist that produce some volumes of cellulosic biofuel, albeit at costs well in excess of the prices of biofuels made of more common feedstocks. Analysis of this policy and its impacts on food prices might be relevant in the event that rapid technological advances lead to quick expansion in cellulosic biofuels as might be intended or hoped. The future of cellulosic biofuel is a matter of speculation. Nevertheless, given the continued focus of policy on cellulosic biofuels and the general belief that they might be neutral with respect to food supplies, there are important research questions that are relevant for policy making.

2. Starting point

2.1. Previous research gives a good base

Existing biofuels hint at complications of the food versus fuel debate. Authors who want to emphasize or de-emphasize the role

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2211-9124/$ - see front matter
http://dx.doi.org/10.1016/j.gfs.2013.03.001

of ethanol in corn markets might represent differently distillers grains that are co-produced with ethanol made from corn and that go back into the food system as an animal feed. Scientific studies have faced their own challenges with co-products as, for example, some early studies treated biodiesel as a product from oilseeds (Birur et al., 2008). However, biodiesel is made from vegetable oils, leaving the oilseed meal co-product free to enter into the food system (Taheripour et al., 2008; Tyner et al., 2010; Meyer et al., 2011; Thompson et al., 2010a).

Further complications are the indirect impacts through land allocation. To some extent, the increase in demand for certain crops and crop products associated with rising biofuel output has caused prices for these commodities to increase relative to what would have occurred if biofuel production had not expanded. Increases in prices of a subset of crops relative to other crops causes reallocation of land towards the uses that generate higher returns. As supplies of other crops decrease relative to what would have occurred without biofuel production expansion, this normal reaction to price signals will tend to cause other crop prices to increase, too. Thus, even crops that are not directly used for biofuel production will experience at least somewhat higher prices in the presence of growing biofuel production relative to what would occur without greater biofuel production. These sort of indirect price effects are closely related to the links that have been studied in greenhouse gas emission impacts of biofuel production because these indirect land use changes might include reallocation of land from carbon storing forest to crop use (Keeney and Hertel, 2009; Thompson, 2010; Wang et al., 2011).

Second generation biofuels are a matter of speculation at this point, although several studies help set out benchmark cases for various possible growth paths (Khanna et al., 2012; Haq and Easterly, 2006; Miranowski and Rosburg, 2010; Hess et al., 2009; Walsh, 2008). Prices link biomass to food, but price impacts depend on the wider context and the policy environment. If petroleum prices are high, for example, then consumers are willing to pay more for biofuels than they are if petroleum prices are low. If policies create subsidies for second generation biofuels or mandate their use, then they are more likely to be profitable. As a biofuel production process becomes widespread, the increased demand for the feedstock to this process is likely to have a more noticeable impact on feedstock costs, as seen in the case of corn starch ethanol. Another possible price effect is on co-products, such as when rising US biodiesel production and co-produced glycerin helped explain a collapse in the glycerin price. Market analysis assesses how new technologies could affect feedstock markets, related commodity markets, and, eventually, food prices.

2.2. The key question

The key question about second generation biofuels that do not have direct effects on traditional crops is whether the indirect price effects tend to increase or decrease food prices. Warm season grasses, such as miscanthus and switchgrass, have been discussed as potential sources of biomass that can be used to make cellulosic biofuel. These are not traditional crops, so even if rising biofuel demand causes rapid increase in the prices of these feedstocks there could be no direct impact on food prices. However, greater returns for allocating land to warm season grass production will draw more land into this use. As more land is devoted to production of second generation biofuel, there will be less land available for growing traditional crops for food production. Discussions of these feedstocks sometimes focus on “marginal land”, arguing that little or perhaps none of the land allocated to such biomass feedstocks will be at the expense of existing agricultural uses. While a one-for-one trade-off with grains, oilseeds, or hay might be unlikely, a zero-for-one trade-off is also an extreme assumption.

Corn stover and wheat straw are co-products, or residue, of grain production that can be used to produce second generation biofuels, at least in theory. If biofuel demand for these agricultural residues were to become substantial, then the returns to allocating land to grain production would be higher. For example, more land allocated to corn means more corn grain and more corn stover, so the effect could be lower corn grain prices, leading indirectly to lower prices for foods made from this commodity. To some extent, the additional corn area would be at the expense of other crops, so there might be increases in other agricultural commodity prices and some offsetting impacts on food prices. The magnitude and even direction of food price impacts in this case are uncertain. Alternatively, second generation biofuel made from wheat straw would tend to increase wheat production, lowering the price of a key food grain.

There are other ways that cellulosic feedstocks could have indirect impacts on traditional agricultural commodities and on food prices or quantities. In particular, there are other inputs aside from land in the production process. For example, fertilizers, farm equipment, capital, labor, and other inputs reallocated to growing warm season grasses would presumably raise the prices of these inputs at least somewhat, leading to some reduction in the supplies of traditional agricultural commodities. There could also be cross effects between corn stover and wheat straw and traditional crops if producers allocate additional inputs in order to harvest these co-products, or to increase their yields. We focus on the role of land based resources as one key input in production and also because this case highlights the potential for very different links between cellulosic biofuel and food.

2.3. Addressing the key question

We use an economic model of biofuel and agricultural commodity markets to address this question. This is a structural economic model that represents how supplies and demands for each good respond to prices and other determining factors. The model simulates market-clearing prices at which total supply equals total demand in each market. The biofuel markets include biodiesel and ethanol. The biofuel use mandates of the RFS are represented as markets for compliance certificates and they may or may not be binding. Corn, wheat, soybeans, and other major annual crops are represented, as are crop products such as soybean oil and meal. Meat and dairy product markets are also represented. Agricultural policies represented in the model include many of the key commodity provisions of the US Farm Bill, such as fixed direct payments, crop insurance, and dairy producer support. The model focuses on the US, but includes rest of world impacts, as well. The model simulates over a 10-year, forward looking period, and the present exercise runs from 2012/13 to 2021/22. This model has been used to study the impacts of biofuel and agricultural policies (Binfield et al., 2012; Meyer and Thompson, 2011, 2012; Thompson et al., 2010a, 2011; Westhoff and Gerlt, 2012) and is documented elsewhere (Gerlt and Westhoff, 2011; Meyer and Thompson, 2010; Meyer et al., 2009; Thompson and Meyer, forthcoming; Thompson et al., 2010b; Westhoff et al., 2006).

Five biomass feedstocks are included in the model: warm season grasses, wheat straw, corn stover, forestry matter, and municipal solid waste. The buyer's willingness to buy biofuels depends on the price of the output, cellulosic biofuel, inclusive of any subsidies, less costs of refining biomass. Biomass and cellulosic biofuel supplies are functions of returns to that use and the costs, which were initially calibrated so that volumes could rise from zero to the full amount mandated by the RFS in 2022 based on