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Effect of corn ethanol production on Conservation Reserve Program acres in the US

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HIGHLIGHTS

- US corn ethanol production led to the conversion of 3.2 million acres of unused cropland to crops.
- One million acres of environmentally sensitive land in Conservation Reserve Program were converted over the 2007–2012 period.
- This represented 16% of the reduction that occurred over this period.

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ABSTRACT

The increase in corn ethanol production has raised concerns about its indirect impacts on the expansion of cropland and implications for the environment and continues to be a controversial issue. In particular, land enrolled in the Conservation Reserve Program (CRP) declined by 7.2 million acres between 2007 and 2012 while corn ethanol production more than doubled. However, the extent to which this decline in CRP acres can be causally attributed to increased ethanol production is yet to be determined. Using a dynamic, partial equilibrium economic model for the US agricultural sector we find that doubling of corn ethanol production over the 2007–2012 period (holding all else constant) led to the conversion of 3.2 million acres of unused cropland, including 1 million acres in CRP, to crop production. While substantial in magnitude, we find that these land use changes due to biofuel production accounted for only 16% and 13% of the total reduction in unused cropland and in CRP acres, respectively, that occurred over the 2007–2012 period. We also find that the land use change per million gallons of corn ethanol has declined non-linearly over time from 453 acres to 112 acres over the 2007–2012 period.

1. Introduction

There has been considerable interest in promoting biofuels as a low carbon, renewable alternative to fossil fuels across the world [1]. However, the production of biofuels from food crops has an unintended consequence of diverting land from food and feed production to fuel production, raising prices of food and feed and converting non-cropland to crop production across the world [2,3]. Assessment of the extent of this land use change due to food crop based biofuels is critical to understanding the trade-offs between food and biofuel production. Several studies have examined the effects of using food crops and non-food, energy crops on land use change and the accompanying effect on food prices [2–6]. These studies show that expanded global biofuel production is expected to reduce land allocated to food crops and raise food prices [2,3] and point out that biofuels produced from dedicated energy crops can mitigate the adverse effects of biofuel production on food prices and provide desirable environmental benefits [4–6]. This paper focuses in particular on examining the extent to which there was conversion of environmentally sensitive land enrolled in the Conservation Reserve Program (CRP) to crop production in the US due to higher crop prices induced by the growth in corn ethanol production in response to the Renewable Fuel Standard (RFS) since 2007.

Corn ethanol production was 6.5 billion gallons in 2007 and more than doubled to 13.2 billion gallons in 2012. Over the same period, studies show that there has been an expansion in cropland acres and a decline in land that was not being used for crop production or had been retired from crop production. This includes land enrolled in the Conservation Reserve Program (CRP) that was retired from crop production for environmental reasons since 1985. USDA's Farm Service Agency data indicate that land enrolled in the CRP declined by 7.2

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million acres, from 36.7 million acres in 2007 to 29.5 million acres in 2012. About 58% of enrolled parcels with expiring contracts chose to exit the program,[1] despite a 24% increase in average land rental payments per acre to land enrolling in CRP between 2007 and 2012. This has raised concern because expansion of cropland on land in CRP or land previously unused for crop production could release carbon stocks in soils and vegetation and create a carbon debt that would offset the greenhouse gas savings achieved by displacing gasoline by biofuels [7–9]. It could also exacerbate other environmental problems such as nitrate run-off and soil erosion that degrade water quality [10].

Satellite data show a decline in land enrolled in the CRP and other types of grasslands and a corresponding increase in cropland in the US since 2007 [11,12]. Wright et al. [13] estimate that 4.2 million acres of non-cropland were converted to crop production within 100 miles of refinery locations between 2008 and 2012; this included 3.6 million acres of converted grassland. These data implicitly implicate corn ethanol as the primary cause of this conversion of cropland since it occurred in the same area as the expansion in ethanol production and/or over the same period of time. Other studies have questioned this implication [14–16]. Barr et al. [15] show that the large increases in cropland rents of 56–64% (2007–2009) in the US were accompanied by very small increases of 0.3–3.0% in total US cropland, implying that crop acreage has been relatively inelastic to biofuel-induced land rent increases.

The above studies have not isolated the extent to which the observed increase in total US cropland can be attributed specifically to the increase in corn ethanol production since 2007. Isolating this impact is complicated because it involves comparison of observed changes in total US cropland and decline in CRP acres with biofuels to an unobserved counter-factual without the increase in biofuels while holding all other factors constant. It also requires estimating the land use impacts simultaneously with the effects on crop prices since the latter influences the returns to cropland and the incentives to expand cropland.

Several studies have used large-scale general and partial equilibrium numerical models to simulate the effect of biofuel policies on food prices and land use [17]. For instance, Searchinger et al. [8] use the Food and Agricultural Policy Research Institute (FAPRI) model to examine the direct and indirect land use changes due to corn ethanol production. Beach and McCarl [18] use the Forest and Agricultural Sector Optimization Model (FASOM) to analyze the least cost mix of alternative biofuels to meet the RFS and their GHG implications. Hertel et al. [19] and Taheripour et al. [20] use the Global Trade Analysis Project (GTAP) model to examine the indirect land use changes on various land use categories due to corn ethanol production. These studies have either assumed that land enrolled in CRP is fixed at 2007 levels [18] or have not specifically examined the implications for acres enrolled in the CRP [20]. Moreover, these studies are estimating land use change due to corn ethanol at a single point in time, and do not consider the dynamics of land use change with increasing production of corn ethanol over time.

A key objective of this paper is to examine the extent to which the observed reduction in CRP acres can be attributed to corn ethanol production over the 2007–2012 period. In particular, we examine the incentives for land enrolled in CRP but with an expiring contract to re-enroll in the program or convert to crop production. In examining the impact of corn ethanol production on CRP acres it is also important to consider other types of land that could have been converted to crop production. We therefore also examine the incentives for converting other unused cropland (not enrolled in CRP) to active crop production. We define unused cropland as land that is intermittently used for crop production and is referred to as land enrolled in CRP and cropland pasture defined by USDA's National Agricultural Statistics Service (NASS). Cropland pasture is either in a crop-fallow rotation or used for pasture and grazing.[2] We distinguish this from cropland which is defined here to include acres in active crop production only.

We undertake this analysis by applying a dynamic, multi-sector, open economy, partial equilibrium economic model, the Biofuel and Environmental Policy Analysis Model (BEPAM), to conduct a with and without analysis of the effect of increased corn ethanol production on the conversion of unused cropland to crop production in the US over the 2007–2012 period [21–23]. We use a dynamic definition of unused cropland that is available for crop production. It is defined as including land enrolled in the CRP with an expiring contract each year. It also includes land categorized as cropland pasture by NASS in 2007. BEPAM integrates the agricultural and transportation fuel sectors in the US to simulate the effects of a policy induced change in biofuel production on the equilibrium prices and quantities in markets for fifteen major crops, eight types of livestock products, three types of biofuels and their by-products and land. A key contribution of our modeling approach is that it incorporates spatially and temporally heterogeneous economic incentives for changes in the allocation of land from one use to another at a crop reporting district (CRD) level for each of the 295 such districts in the US.

We extend BEPAM to examine the extent to which corn ethanol production might have led to an increase in crop prices and induced the conversion of unused cropland to crop production, and/or to changes in cropland use as acreage shifted from one crop to another crop. The dynamic optimization model enables us to incorporate the choice for land enrolled in CRP with expiring contracts to return to crop production or re-enroll in the program by comparing the future stream of returns to land between the two choices. To isolate the impact of corn ethanol production on the expansion of cropland and on crop prices, we simulate two scenarios with the BEPAM that differ in their levels of ethanol production, while keeping all other modeling assumptions the same. Scenario 1 keeps "Ethanol fixed at the 2007 level", while in Scenario 2 "Ethanol is at the observed levels with RFS". More specifically, Scenario 1 maintains corn ethanol production at the 2007 level of 6.5 billion gallons for the duration of the 2007–2012 period. In Scenario 2, corn ethanol production increases from 6.5 billion to 13.2 billion gallons over the 2007–2012 period as observed under the RFS. We compare outcomes in these two scenarios to estimate the extent to which the increased demand for corn ethanol led to an increase in crop prices and created incentives for land in CRP and in cropland pasture to convert to annual crop production during the 2007–2012 period. Our analysis incorporates the changing availability of CRP acres with expiring contracts for conversion to crop production in each of the years as these acres choose whether to re-enroll in the program or to revert back to crop production. It also incorporates the dynamics of the increase in corn ethanol production over time and the increase in corn acreage for ethanol production over time.

Our analysis makes several contributions to the existing literature examining the impact of corn ethanol production on land use. First, it explains the extent to which the decline in CRP acres between 2007 and 2012 can be attributed directly to corn ethanol. It examines this by focusing on land that could most easily be converted to cropland (that is, expiring CRP acres and cropland pasture) in response to higher returns to land induced directly by corn ethanol production. Second, it estimates the elasticity of land use change due to higher prices induced by corn ethanol production. It thereby seeks to reconcile the two strands of literature described above that finds substantial conversion of non-cropland to crop production but also an inelastic response of crop acreage to crop prices. Third, the dynamic view of land use change

[1] https://www.fsa.usda.gov/programs-and-services/conservation-programs/reports-and-statistics/conservation-reserve-program-statistics/index.

[2] For definitions of different land uses, see page 17 of the following document https://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_1_US/usappxb.pdf