SPATIAL EFFECTS OF CARBON PRICING ON AGRICULTURE AND BIOENERGY IN THE UNITED STATES

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Overview

On January 24th, 2019, the Energy Innovation and Carbon Dividend (EICD) Act of 2019 was introduced to the House of Representatives. The Act proposes a carbon tax of $15 per ton of carbon dioxide equivalent (CO_2-e) covering entities such as refineries, coal mines, or natural gas producers. The carbon tax would increase by $10 each year and is subject to adjustments given the under- or over-achievement of annual emission reduction targets. The bill has bipartisan support and is co-sponsored by Republicans and Democrats. On January 17th , 2019, a high-profile group of economists has signed a statement recommending a carbon tax and the return of the tax revenue to citizens in form of a lump-sum payment.[1] In view of the policy proposal imposing a carbon tax on energy providers, we will analyze the effects of such a policy on the agricultural sector in the United States under various macroeconomic conditions with regard to oil prices and economic growth. We will assess changes in average farm income at the county-level over the next ten years under the carbon tax proposed in the EICD Act. In addition, the effects on commodity prices and land-use will be quantified. Given the discussion about the sectoral effects of any carbon policy, we aim at outlining the effects on U.S. agriculture. Any policy proposal to curb climate change needs to address distributional effects on stakeholders (e.g., farmers in our case) using energy-intensive inputs. There will be different effects on farmers depending on the location due to spatial differences in production cost and yields. The carbon policy will also have implications on the consumption of corn ethanol, biodiesel, gasoline, and diesel in the road transportation sector. The former will influence the demand for corn and thus, the revenue for farmers. Our model will inform policy makers, farmers, and other stakeholder on the effects of the carbon tax and can contribute to a better understanding of the consequences at the regional/local level.

Methods

We develop a dynamic rational expectations model for barley, corn, sorghum, soybeans, and wheat at the county level in the United States. Each county is characterized by a representative farmer who allocates land to the commodities based on net returns. Agriculture is a perfectly competitive market and hence, all farmers are price takers and do not take the effect of their acreage decision on output prices into account. In aggregate, the net returns dynamics are endogenous to the model and commodity prices are set at the national level.

Demand for each crop is composed of the food, feed, export, and (depending on the crop) biofuel sector. For each sector, demand is modeled as a constant elasticity function depending on commodity prices (own price and prices of other crops), real disposable income, and population. The elasticity parameters are calibrated based on estimates from the literature. On the production side, we have location-specific cost functions which depend on the crop as well as the prices for oil, natural gas, and the carbon tax. The cost functions are calibrated based on data from the U.S. Department of Agriculture (USDA) Cost and Returns database. Note that the EICD Act exempts farm fuel use and agricultural greenhouse gas (GHG) emissions (e.g., emissions from enteric fermentation from livestock or nitrous oxide emissions from agricultural soil management) from the carbon tax. Those exemptions are included in our model. Because the carbon tax is affecting energy intensive inputs, effects of higher fertilizer prices will be more pronounced for corn and wheat than for soybeans. Corn and wheat are fertilizer intensive and the share of fertilizer cost (i.e., as a fraction of total production cost) is higher compared to soybeans. This may lead to farmers moving between crops resulting in changes in supply and – subsequently – net returns. Given the acreage decision by farmers that are engaged in the production of the five crops in our model and demand parameters, we can calculate the equilibrium prices over the projection period. In the simulation part of our model, we solve for prices of the commodities that clear the market over time by allowing unprofitable land to withdraw from production and be put into the Conservation Reserve Program (CRP). Our model is also coupled with a road transportation model presented in Dumortier et al. (2017) to assess the effects of the carbon tax on vehicle miles travelled and the consumption of corn ethanol and biodiesel.

The data for the model calibration are based on various sources. The macroeconomic assumptions are based on projections from the U.S. Energy Information Administration (EIA) 2019 Annual Energy Outlook (2019

[1] The group is comprised of former Federal Reserve Chairs, Nobel Laureates in Economics, Council of Economic Advisers chairs, and two former secretaries of the U.S. Department of Treasury. Full statement: "Economists' Statement on Carbon Dividends" in the Wall Street Journal.

AEO). The 2019 AEO projections consider a reference case with status-quo energy policies as well as various scenarios differentiated by changing energy policies, different technological and economic growth paths as well as low and high oil prices. In our model, we include the reference case and four scenarios: (1) high economic growth, (2) low economic growth, (3) high oil price, and (4) low oil price. For each case (i.e., reference case and scenarios), we impose a carbon tax as suggested in EICD Act to determine not only the spatial differences in net returns but also how those change based on the macroeconomics environment.

A carbon tax affects the economy and thus, we need to find an adequate source of macroeconomic parameters and projections under the tax to ensure the reliability of our results. Because a carbon tax has not yet been implemented in the U.S., only a simulation model can provide the data. For this analysis, we base our carbon tax scenarios on the Annual Energy Outlook (AEO) published by the U.S. Energy Information Administration (EIA), which has simulated the effects of a tax on carbon in the past and can serve as a source of parameters.

The crop area and yield data are obtained from the National Agricultural Statistics Service (NASS) of the USDA. The Economic Research Service (ERS) from the USDA provides data about the historical cost and returns for major commodities. Given the yield, area, commodity prices and production costs, we can calculate the average profitability of land in each county while in agricultural production. The ERS also provides data about the average payments per county for land in the CRP. This allows us to determine the profitability of taking land out of production and into CRP. To calculate the domestic demand in the United States, we rely on the demand parameter estimates from the literature as well as the Center for Agricultural and Rural Development (CARD) at Iowa State University. The demand equations are used to project U.S. and export demand over the projection period.

Results

We expect the results to be largely dependent on the macroeconomic environment and oil prices. We assess a baseline (EIA reference case) and compare it to the abovementioned scenarios. Preliminary estimates indicate the highest increase in production cost across all our scenarios for corn by 16.4% at a carbon tax of \$105 t^{-1} CO_2-equivalent. This is mostly due to the increase in the price of natural gas which serves as an input in the production of fertilizer. The smallest increase is observed for soybeans, which increases by 11.9%. Although farmers face higher production cost, the effect on profitability, i.e., market net return, of crop production is lessened due to an increase in the commodity prices and a decrease in total area. Overall crop area in the U.S. declines by 0.4% at the end of the projection period. Barley and sorghum decrease between 2.3% and 2.4% in the scenario whereas corn and soybeans decrease by 0.9% and 0.1%, respectively in the scenario. The carbon tax mostly impacts fertilizer and thus, it will not be profitable to use marginal cropland. Our preliminary results suggest an increase in the variable cost of for corn by 20.8 in USDA's Heartland (i.e., U.S. Midwest) region. Excluding fertilizer from the carbon tax, the cost increase is reduced to 7.1% and 5.9% in the Midwest and the U.S., respectively. We hypothesize that the carbon fee will result in higher prices for consumers which partially compensates farmers for the higher input costs.

Conclusions

The discussion over the last decade has focused on using a cap-and-trade mechanism to regulate GHG emissions in the United States and the current debate focuses more on a carbon tax. Similar discussions are also present in Canada (Slade, 2018). A previous study has been conducted over a decade ago at the national level but did not include consequences at the regional (i.e., county) level (Schneider and McCarl, 2005). We believe that the renewed interest in imposing a carbon tax and its effects on agriculture are of interest to the IAEE annual meeting participants. Our analysis contributes to understanding the income effects but before any carbon tax passes in the U.S., there will be many other proposals (e.g., carbon offsets and credits) that will affect agriculture.

References

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