U.S. Climate Policy Revisited: Spatially Distributed Spillover Effects on Agricultural Production, Trade and Land Use

Uris Baldos, Maksym Chepeliev, Iman Haqiqi, Thomas Hertel, Jing Liu, and Dominque van der Mensbrugghe
Center for Global Trade Analysis, Purdue University

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Abstract

Agriculture is the largest emitter of non-CO_2 greenhouse gas emissions, but it seems unlikely that these emissions will be covered by climate policies in the near future. However, even if carbon pricing were applied to CO_2 emissions alone, as is the case with the EU emissions trading scheme (ETS), the agricultural sector would be impacted through the increasing costs of intermediate energy inputs, rising fertilizer prices and changing food demand in response to changing prices and incomes. Considering the tremendous heterogeneity of agricultural production systems across the continental U.S., it is also important to not only understand the potential macroeconomic and sectoral implications of the climate mitigation measures, but also the spatial distribution of the corresponding impacts. In this paper, we apply a harmonized macro-gridded modeling framework to provide an assessment of spatially distributed spillover effects of climate mitigation policies on U.S. crop sector. Our results suggest that even if mitigation measures would be implemented in a form of CO_2 pricing only (i.e. non-CO_2 GHGs would not be directly targeted), the crop sector would be impacted through a number of channels, with rising fertilizer prices being the key one. Overall, we find substantial environmental co-benefits achieved through this channel and resulting in a reduction of cropland use, nitrogen leaching and water withdrawals. In particular, we find that such a climate policy would yield substantial water quality co-benefits, mitigating nitrate leaching to a greater extent than current voluntary environmental policies targeting water quality directly.

1. Introduction

Virtually all of the countries in the world signed the 2015 Paris Agreement whose objective is to "hold the increase in the global average temperature to well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels" (UNFCCC, 2021). As such, 194 parties, including the European Union (EU), have submitted their individual commitments, also called the Nationally Determined Contribution (NDC), and action plans to achieve their goals through 2030. Thirteen parties have revised their initial commitment and submitted a second NDC (UNFCCC, 2021). While it is widely recognized that the current NDC commitments are not ambitious enough to limit global warming below 2°C (Rogelj et al., 2016), the Paris Agreement represents a crucial step towards global cooperation to take actions to limit climate changing emissions.

Since the signing of the Paris Agreement, climate policies have been diverging among top global emitters. While the EU has proceeded with developing ambitious mitigation plans under the EU Green Deal proposal, U.S. climate policy has been in a phase of considerable flux. The Trump administration withdrew from the Paris Agreement and relaxed environmental regulations, providing more support to fossil fuels.

The Biden administration has stated ambitious climate plans. These include carbon free electricity by 2035 and reaching net zero emissions by 2050, which would be just in a range to be compatible with the 2ºC mitigation effort. One of the first moves of President Biden was to have the U.S. rejoin the Paris climate accord. Although bringing multiple benefits to the environment and public health, implementation of the NDC and more stringent climate mitigation targets would result in additional costs to the U.S. economy, not for the key fossil-fuel users, like heavy manufacturing, transportation and electricity generation, but also through indirect implications for agricultural and food systems.

Agriculture is the largest emitter of non-CO_2 greenhouse gas emissions, but it seems unlikely that these emissions will be covered by climate policies in the near future. However, even if carbon pricing were applied to CO_2 emissions alone, as is the case with the EU emissions trading scheme (ETS), the agricultural sector would be impacted through the increasing costs of intermediate energy inputs, rising fertilizer prices and changing food demand in response to changing prices and incomes. Considering the tremendous heterogeneity of agricultural production systems across the continental U.S., it is also important to not only understand the potential macroeconomic and sectoral implications of the climate mitigation measures, but also the spatial distribution of the corresponding impacts. This paper is part of an organized session, where we apply a harmonized macro-gridded modeling framework to provide an assessment of spatially distributed spillover effects of climate mitigation policies on U.S. agriculture. Four papers within this session explore different dimensions of interactions between climate mitigation and agricultural systems (Figure 1), including (a) impacts on production, trade and land use; (b) implications for nitrogen use and nitrate leaching; (c) impacts on irrigation; and (d) potential for relaxing Renewable Fuel Standards (RFS2). This first paper provides an introduction to the methodological framework, as well as discusses climate policy implications for agricultural production, trade and land use.

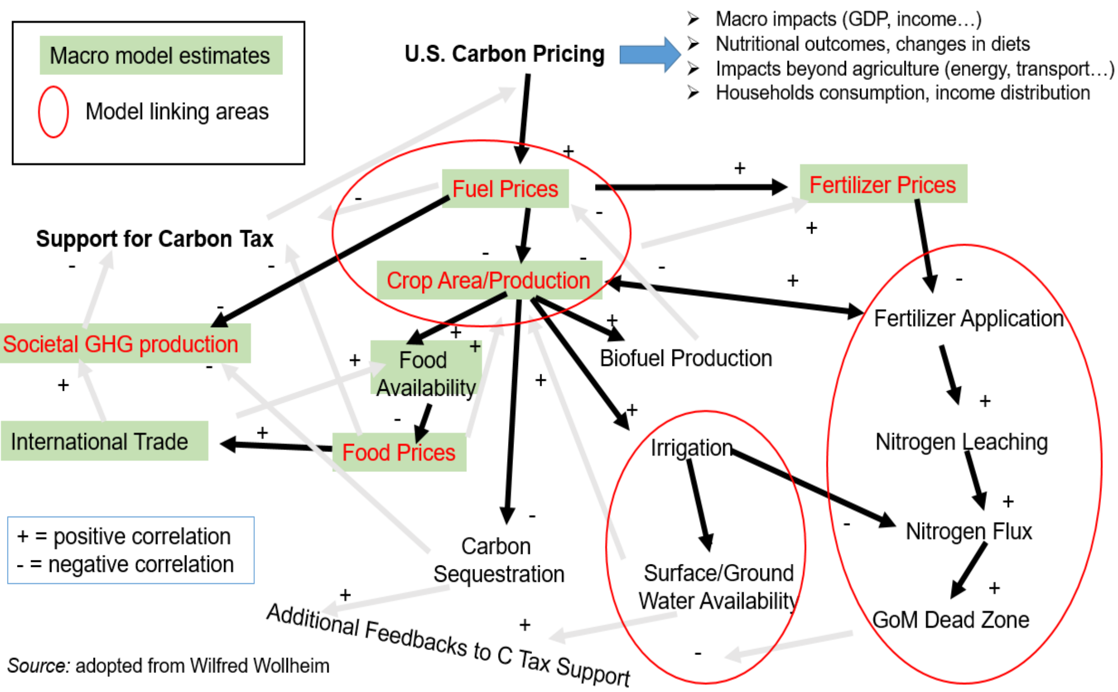

Figure 1. Carbon pricing interactions with agriculture

2. Data and Methods

For the analysis we link a static global computable general equilibrium (CGE) model ENVISAGE (van der Mensbrugghe, 2019) with the SIMPLE-G Corn-Soy Model (Simplified International Model of agricultural Prices, Land use, and the Environment-Gridded version) (Baldos et al., 2020). We consider a range of carbon pricing scenarios, which are implemented by the US and/or its trading partners. Such set up allows us to derive the carbon pricing response curves (for different indicators under different carbon price levels) using the ENVISAGE CGE model. We then link these outcomes (e.g. changes in the price of natural gas, electricity, ammonia, etc.) to the SIMPLE-G Corn-Soy modelling framework by transferring selected indicators estimated by ENVISAGE (Figure 2). SIMPLE-G uses these indicators as an input shocks to the modelling framework to provide a detailed gridded-level (48,332 grids of 5 arcmin) assessment of the national and international climate mitigation policies on U.S. agriculture, including implications for crop production, cropland cover, nitrogen use and water use.

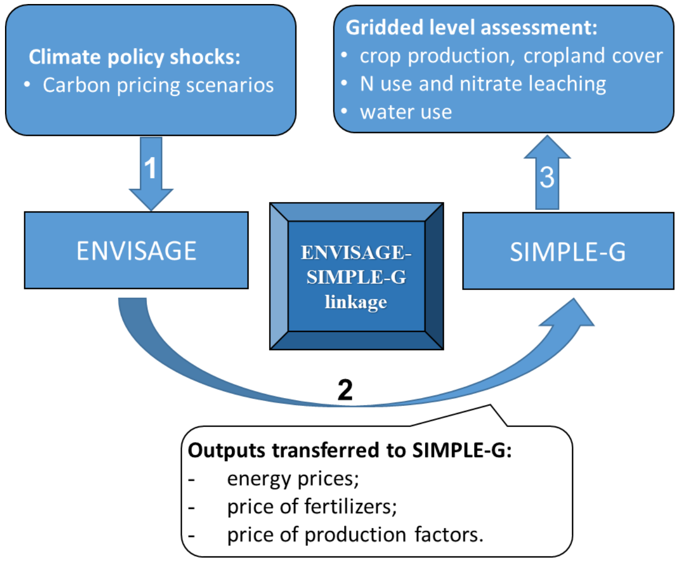

Figure 2. Overview of the overall approach to the ENVISAGE-SIMPLE-G models' linkage

3. Results

Our preliminary results, based on the case of U.S.-only mitigation policy, indicate that an introduction of carbon pricing would impact agricultural sector primarily through the increase in the cost of ammonia fertilizer, where natural gas represents over 50% of the cost structure (Figure 3). For instance, under the $100/t$CO_2$ carbon price, which is close to the $85/t$CO_2$ observed in the EU ETS at the end of 2021, the price of natural gas would increase by around 125%, which would translate to a 64% increase in the cost of ammonia production. Lower cost increases are observed for other important energy commodities used in agriculture – petroleum products (+33%) and electricity (+18%). The latter is a more important driver for the irrigated agriculture, since water pumping is an electricity-intensive activity, especially in selected U.S. states.

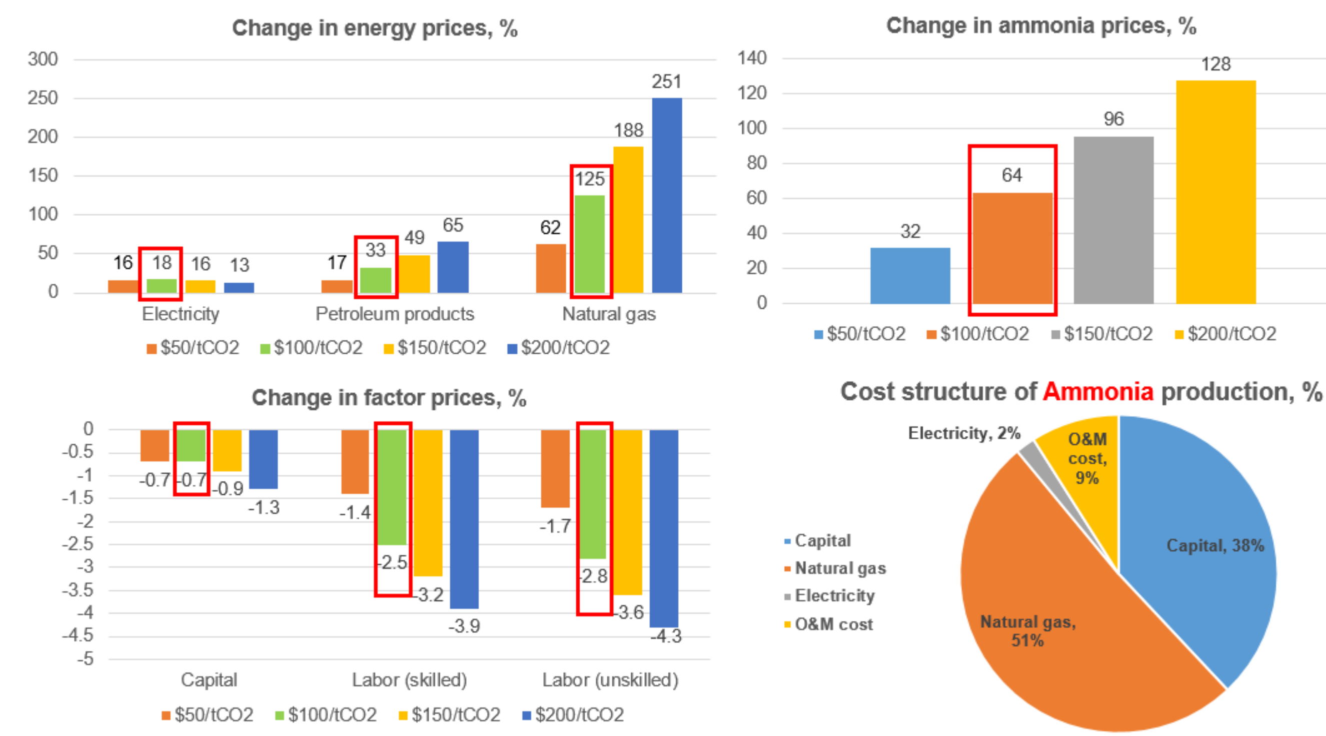

Figure 3. Selected macro and sectoral impacts of U.S. carbon pricing scenarios

Source: Estimated by authors using ENVISAGE model.

Transferring selected outcomes from ENVISAGE climate policy simulations to the SIMPLE-G-US Corn-Soy model, we find that rising costs of crop production, mainly through nitrogen fertilizer prices, lead to spatially heterogeneous reductions in crop output and cropland use (Figure 4). Crop production moves from U.S. to the Rest of the World with a "leakage" rate of around 55%, since in this US-only scenario there are no carbon border adjustment measures. Since the cost share of nitrogen fertilizer input is generally higher in rainfed production (compared to the irrigated agriculture), we find more substantial impacts of the carbon pricing policies for the Corn Belt and Lake States (Figure 4).

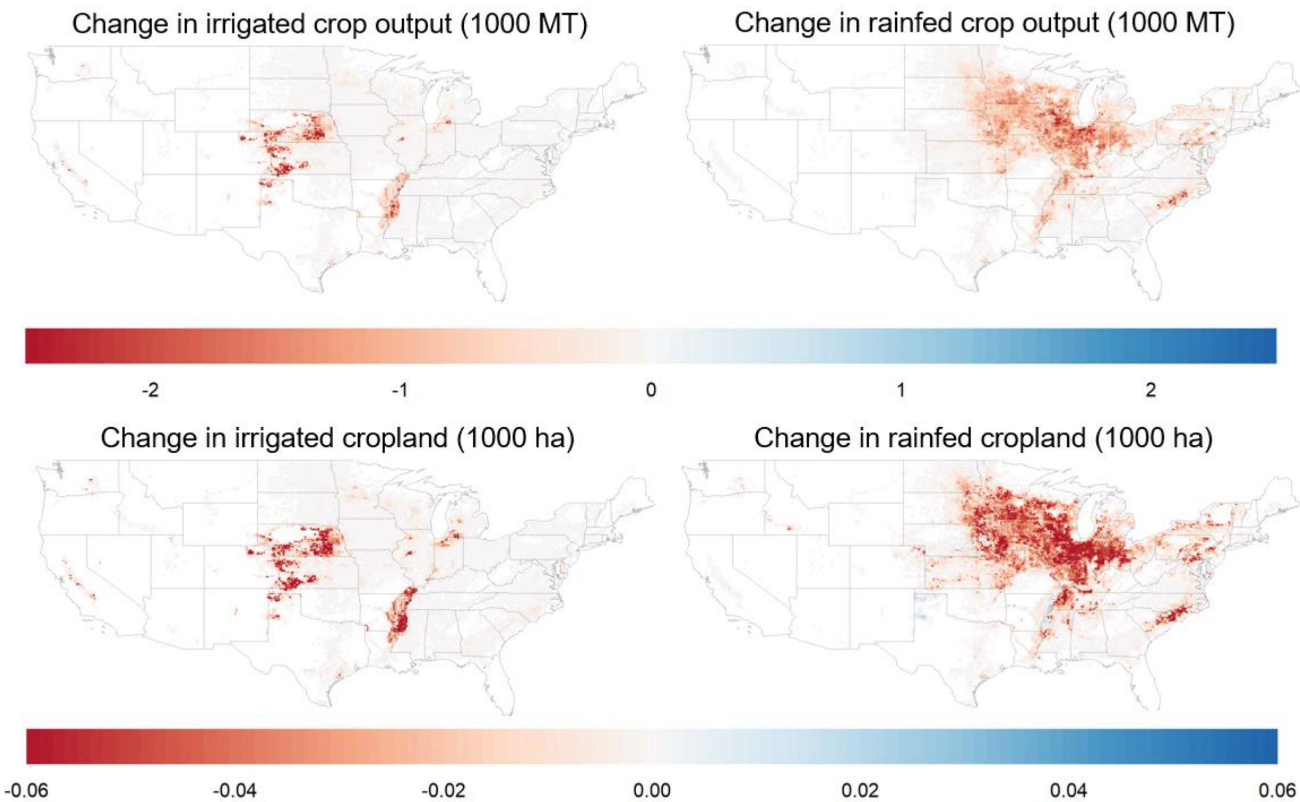

Figure 4. Change in U.S. crop output (top row) and cropland (bottom row) under \$100/tCO_2 carbon price scenario (irrigated vs rainfed crops)
Source: Estimated by authors using SIMPLE-G-US Corn-Soy model.

4. Conclusions

In this paper we apply a macro-gridded modeling framework to provide an assessment of climate mitigation policies on U.S. crop sector. Our results suggest that even if mitigation measures would be implemented in a form of CO_2 pricing only (i.e. non-CO_2 GHGs would not be directly targeted), the crop sector would be impacted through a number of channels, with rising fertilizer prices being the key one. Overall, we find substantial environmental co-benefits achieved through this channel and resulting in a reduction of cropland use, nitrogen leaching and water withdrawals. In particular, we find that such a climate policy would yield substantial water quality co-benefits, mitigating nitrate leaching to a greater extent than current voluntary environmental policies targeting water quality directly.

Further extensions of our analysis will include consideration of a wider set of climate mitigation scenarios, where EU and other U.S. trading partners implement more ambitious abatement measures, as well as representation of the border carbon adjustment measures by U.S. and EU. Increasing the scope of all US crop production will be considered.

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