Precision agriculture incentives and biofuel pass-through: how food and fuel can feed a Canadian net-zero world.

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Abstract:
The â€œFood versus Fuel" debate antagonises biofuel production claiming that it raises food prices. However, biofuels could reduce GHG emissions by up to 410-640 MtCO2eq per year in the USA and have already accounted for 11.4 MtCO2 avoided emissions in the Canadian transportation sector in 2023. Transportation and agriculture accounted for a combined 45% of Canadian GHG emissions in 2021, indicating the need to abate emissions in both sectors in light of Canada's net-zero pledge by 2050. Precision-agriculture (PA) technologies, such as machine guidance and variable rate input application, reduce on-farm fuel and fertiliser use and could reduce feedstock costs to biofuel production through increased productivity. Therefore, would incentivising PA increase biofuel demand, lower food prices, and reduce agricultural and transportation emissions to reach net-zero equitably and sustainably? We quantify PA adoption in agriculture, biofuel uptake in transportation, food prices, and their impact on reducing non-CO2 and CO2 emissions when Canada achieves net-zero by 2050 using Environment Canadaâ€™s Multi-Sector, Multi-Region (EC-MSMR) recursive-dynamic Computable General Equilibrium (CGE) model. EC-MSMR features 32 intermediate demand sectors, 5 final demand sectors, and 17 regions. We test the robustness of our conclusions with and without land mobility across non-agricultural sectors, temperature-related economic damages, and stochastic crop production growth. We estimate results relative to a base case in which Canada achieves net-zero by 2050 without PA. We use OLS to estimate crop-specific PA input costs using the 2023 USDA Census of Agriculture and assuming Cobb-Douglas production. We calibrate EC-MSMR to GTAP 11 and StatCan 2017 supply-use tables (SUT) as well as E3MC's 2023 reference case emissions and energy supply and use data. We estimate region-specific and crop-specific AR processes of crop production with endogenous lags using FAOSTAT 2023 regional crop production data and test asymptotic robustness of estimates through bootstrapping. We disaggregate eight crop agriculture sectors using GTAP 11 shares applied to the 2017 StatCan SUT and E3MC on farm fuel use estimates in which crop agriculture is aggregated and employ a partial equilibrium rebalancing routine. We account for temperature-related economic damages by leveraging Bilal & Kanzig (2024)'s OLS methodology for estimating damages to global GDP to estimate damages to capital and labour productivity by region using Berkeley Earth temperature anomalies and Penn-World Tables capital and labour productivity. We forecast global average temperatures by passing endogenous emissions from EC-MSMR to the FAIR 1.6.2 climate emulator as in Van der Mensbrugghe et al. (2024) and combine this endogenous temperature with our estimated coefficients to inform damages to each input. Our study is the first to posit the effectiveness of PA in achieving net-zero targets, to estimate the relative cost of PA technologies by input by crop, account for temperature-related economic damages to factor inputs within a CGE framework, and assess the LULUCF implications of PA and increased biofuel production using the

GTAP 11 land use and land cover database. Finally, we test the robustness of PA with stochastic processes that deviate from initial StatCan 2017 production estimates. We find that when Canada achieves net-zero with PA, consumption increases by up to 1.34%, crop production increases by up to 32.04%, and food prices would reduce by up to 1.47% relative to net-zero without PA. Road transportation biofuel use increases by up to 14.75%, road transportation CO2 emissions fall by up to 16.85% by 2050, and agricultural N2O emissions intensity decreases by up to 14.41%. We find that this is robust to fluctuations in agricultural production growth as deterministic crop and food prices approach the upper bound and crop production approaches the lower bound of their respective within-year distributions. Our study responds to SDG 7, 11, and 13 showing that PA incentives unlock emissions-abatement by increasing Canadian biofuel affordability while reducing food prices. Our study responds to SDG 7, 11, and 13 showing that PA incentives unlock emission reduction by increasing the affordability of Canadian biofuels while reducing food prices.