



Global Agricultural Market and Land-Use Implications of Producing Sustainable Aviation Fuel from Second Crop Corn Ethanol in Brazil

Amani Elobeid, Iowa State University, USA

Miguel Carriquiry, Universidad de la Republica, Uruguay

Luciane Chiodi Bachion, Agroicone, Brazil

Sofia Marques Arantes, Agroicone, Brazil

Jerome Dumortier, Indiana University, USA

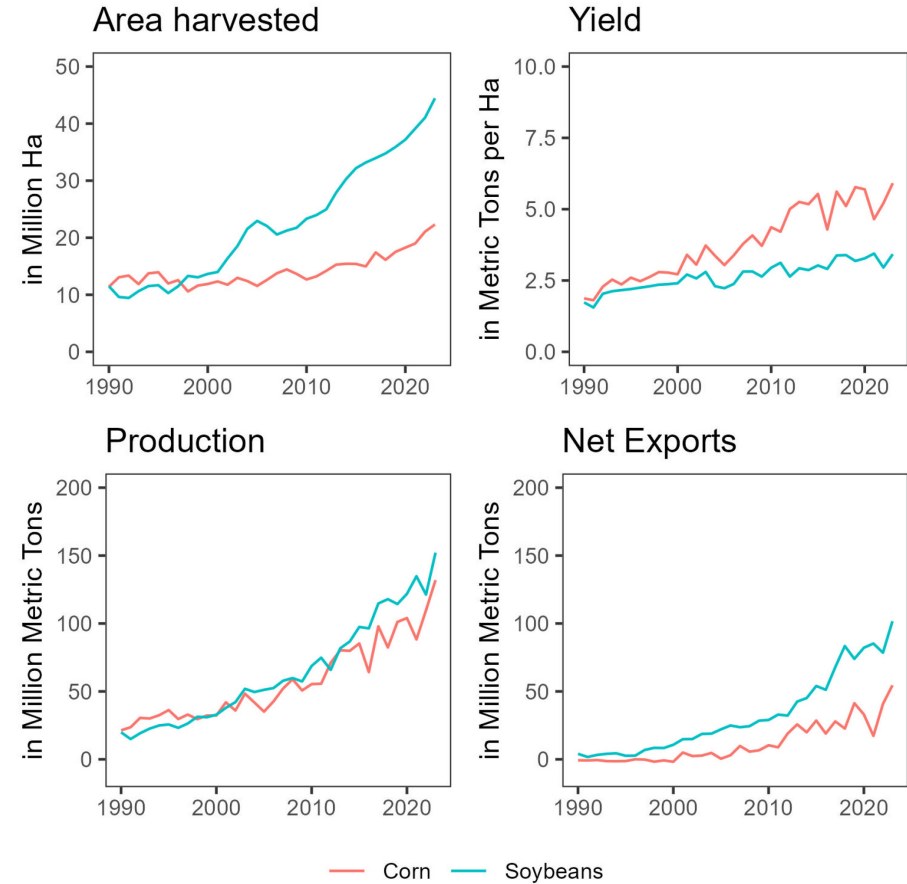
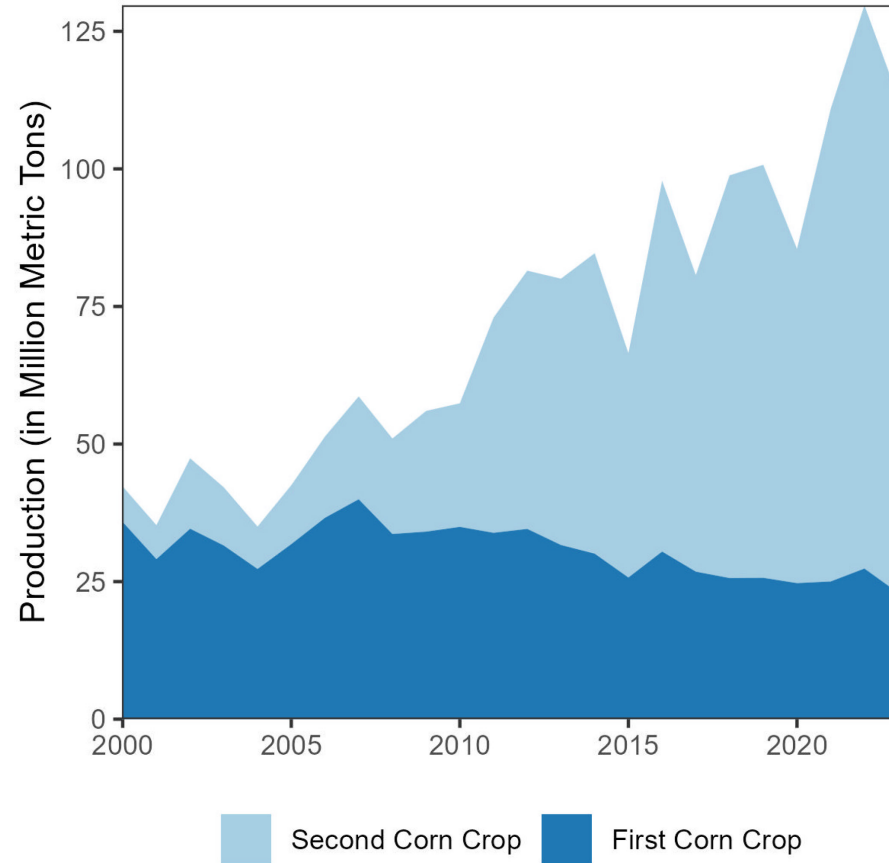
Summary

- Brazilian ability to produce second crop corn on soybean area previously harvested in the same season
- Modification of an agricultural model to quantify effects of increased second crop corn production on global markets and emissions from land-use change
 - Scenarios: Ethanol demand growth, corn supply elasticity, and trade constraints
- Results
 - Potentially moderate impacts on global markets and emissions from higher corn production
 - Potential for low carbon Sustainable Aviation Fuels (SAF) from Brazilian corn

Background

- Increasing importance of corn ethanol production in Brazil
- Corn ethanol greenhouse gas (GHG) calculations mostly conducted for United States (U.S.) but not Brazil
- Key difference between Brazilian and U.S. corn ethanol production
 - Use of second crop corn in Brazil
 - Use of renewable energy to fuel Brazilian ethanol plants as opposed to natural gas in the U.S.
- Absence of second crop corn in most agricultural modeling systems
 - Inability to capture area dynamics for soybeans resulting from second crop corn

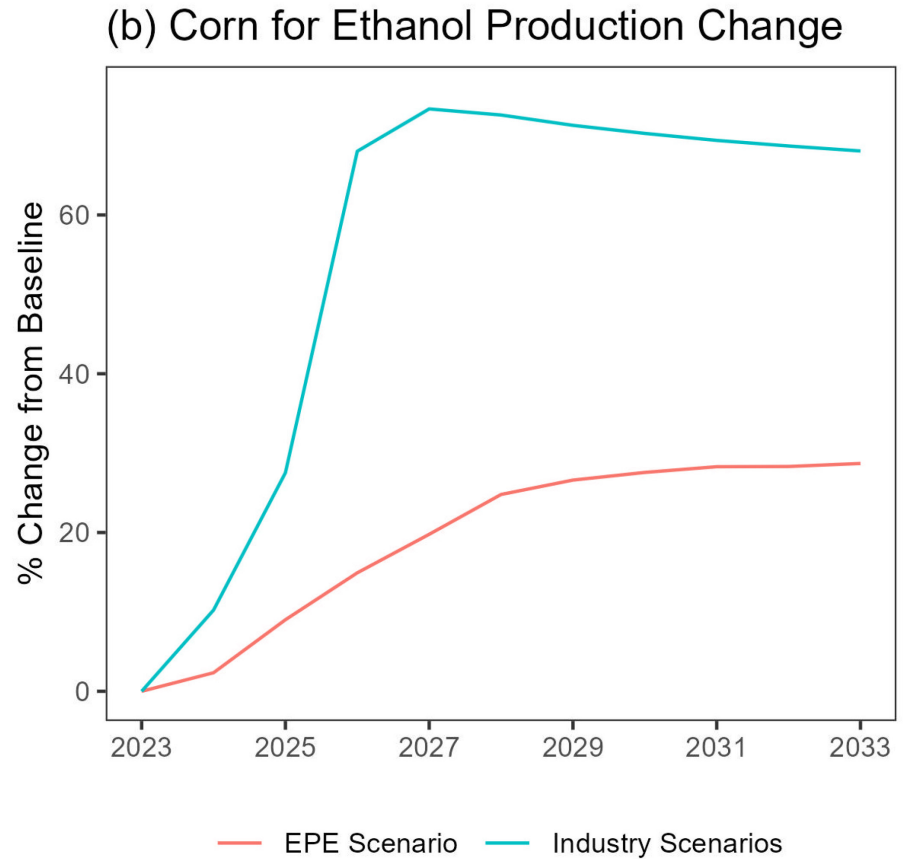
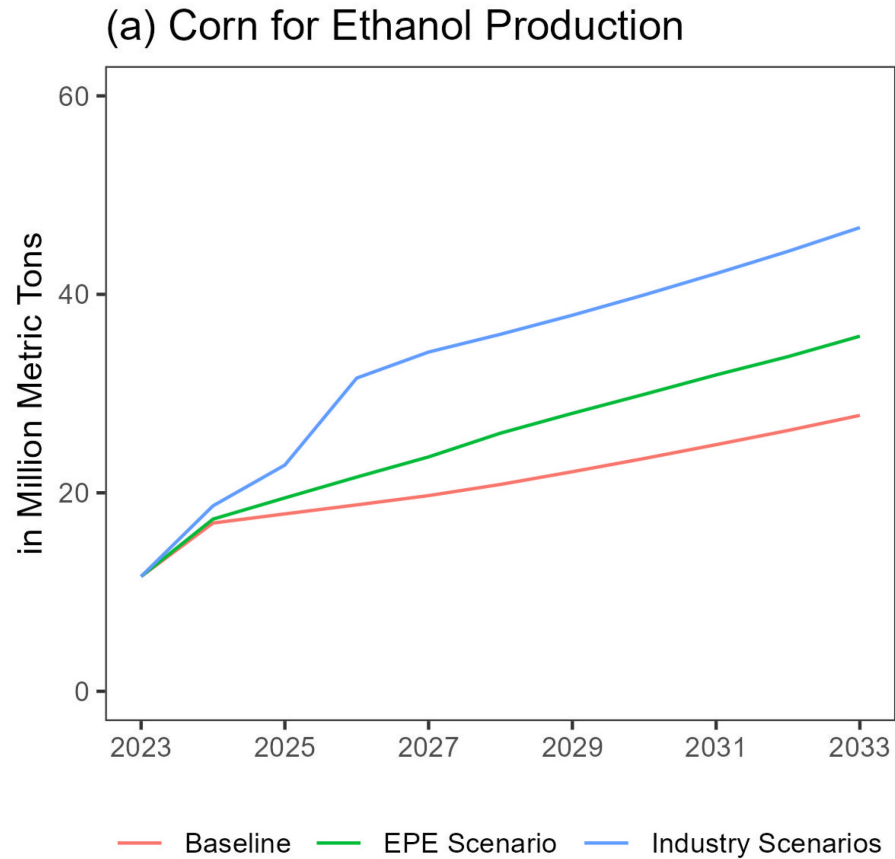
Double-Cropping Corn in Brazil



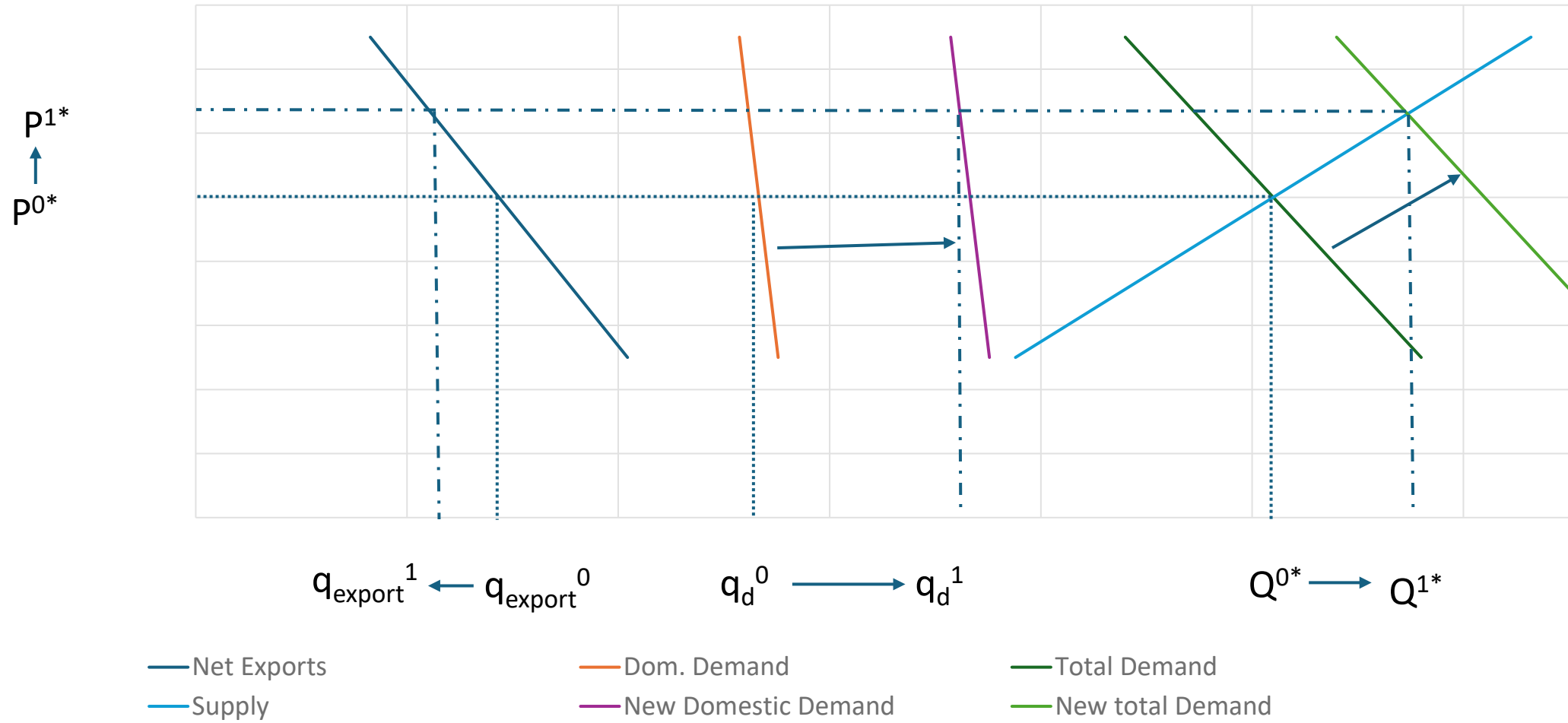
Scenarios

- Sources
 - EPE (Empresa de Pesquisa Energética): Brazilian policy research institution
 - IND: Industry projections pointing to even higher levels of ethanol expansion
- Scenario descriptions (besides the baseline of no corn ethanol expansion)
 - *EPE Scenario*: High growth corn ethanol scenario
 - *IND Scenario*: Growth beyond EPE Scenario
 - *IND Fixed Exports*: Brazilian exports fixed at the baseline level
 - *IND Perfect Elasticity*: Second corn crop area perfectly own-price elastic
- Equilibrium year: 2033

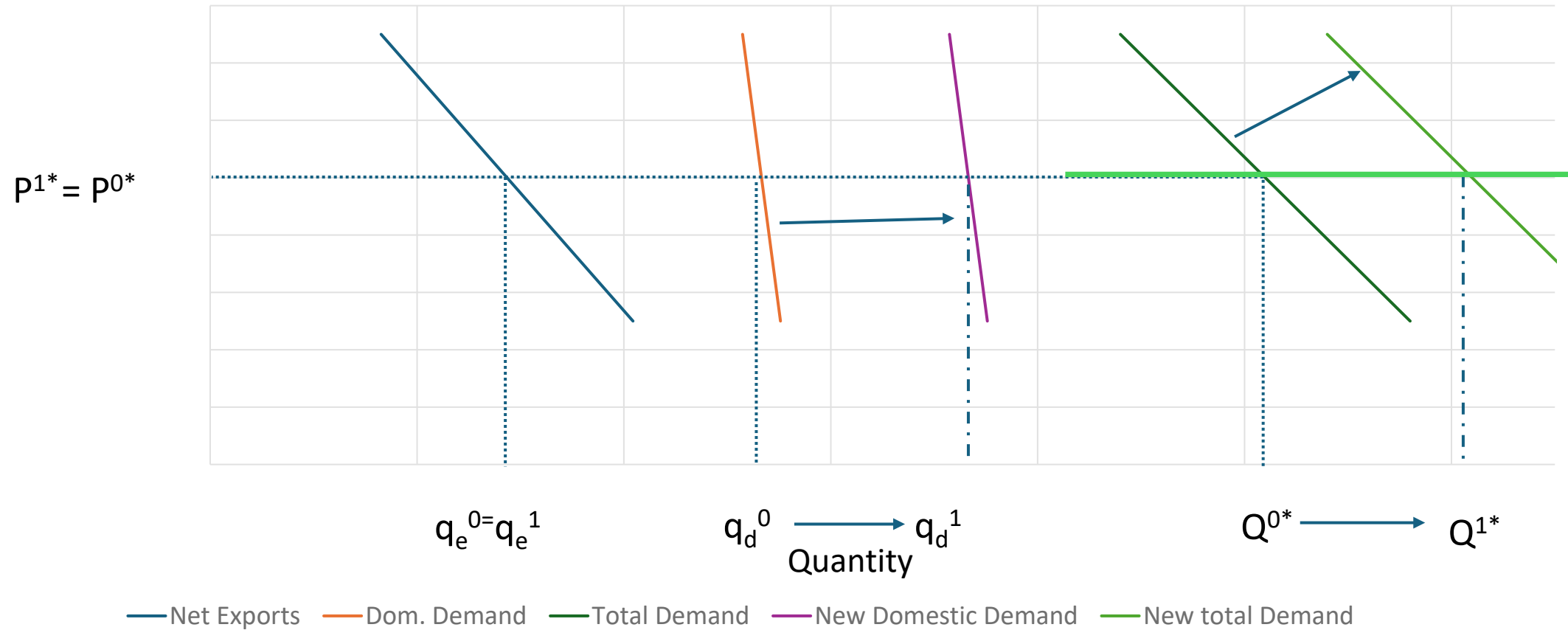
Scenario Impact on Corn Production



Scenario Mechanics: Corn Demand Increase Only



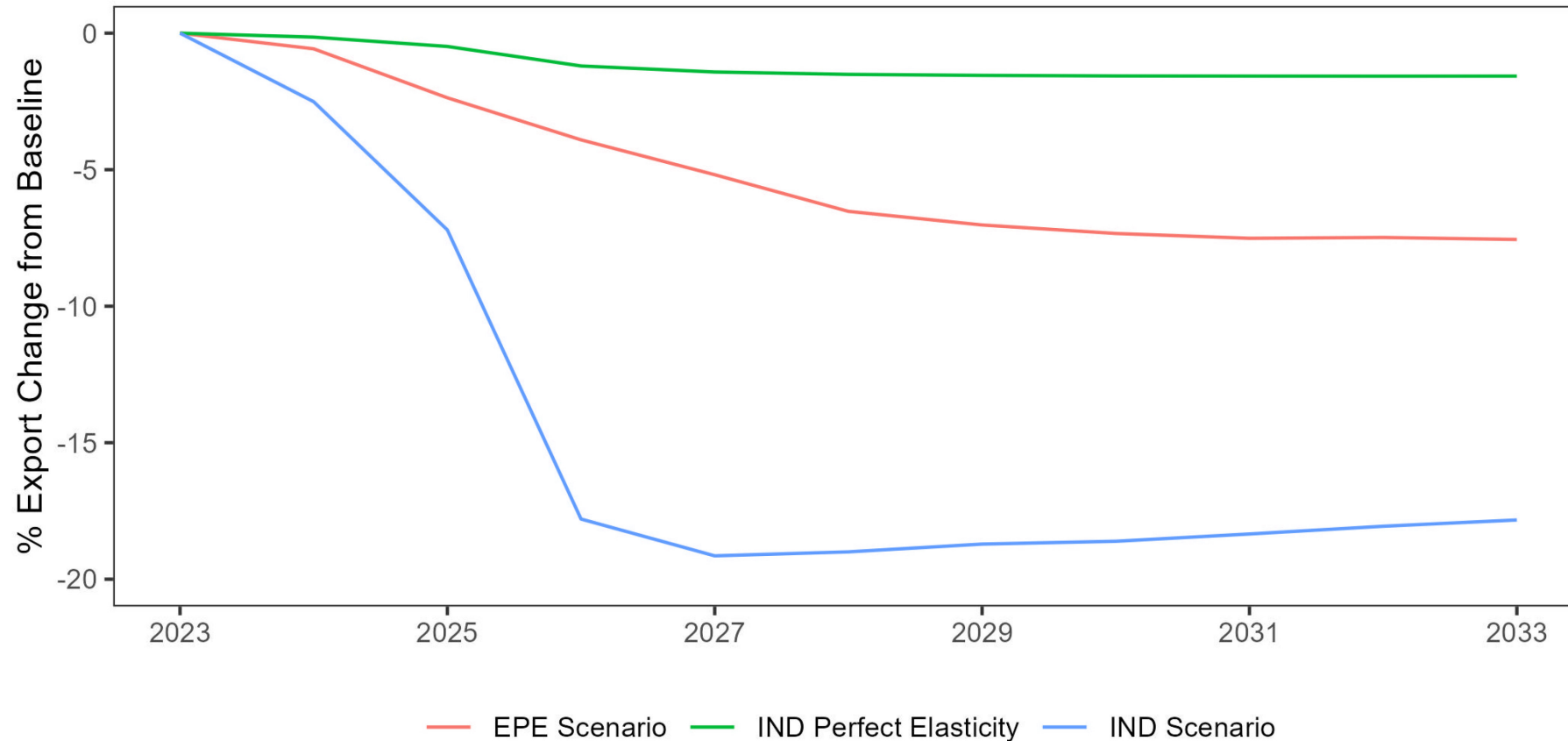
Scenario Mechanics: Perfect Elasticity



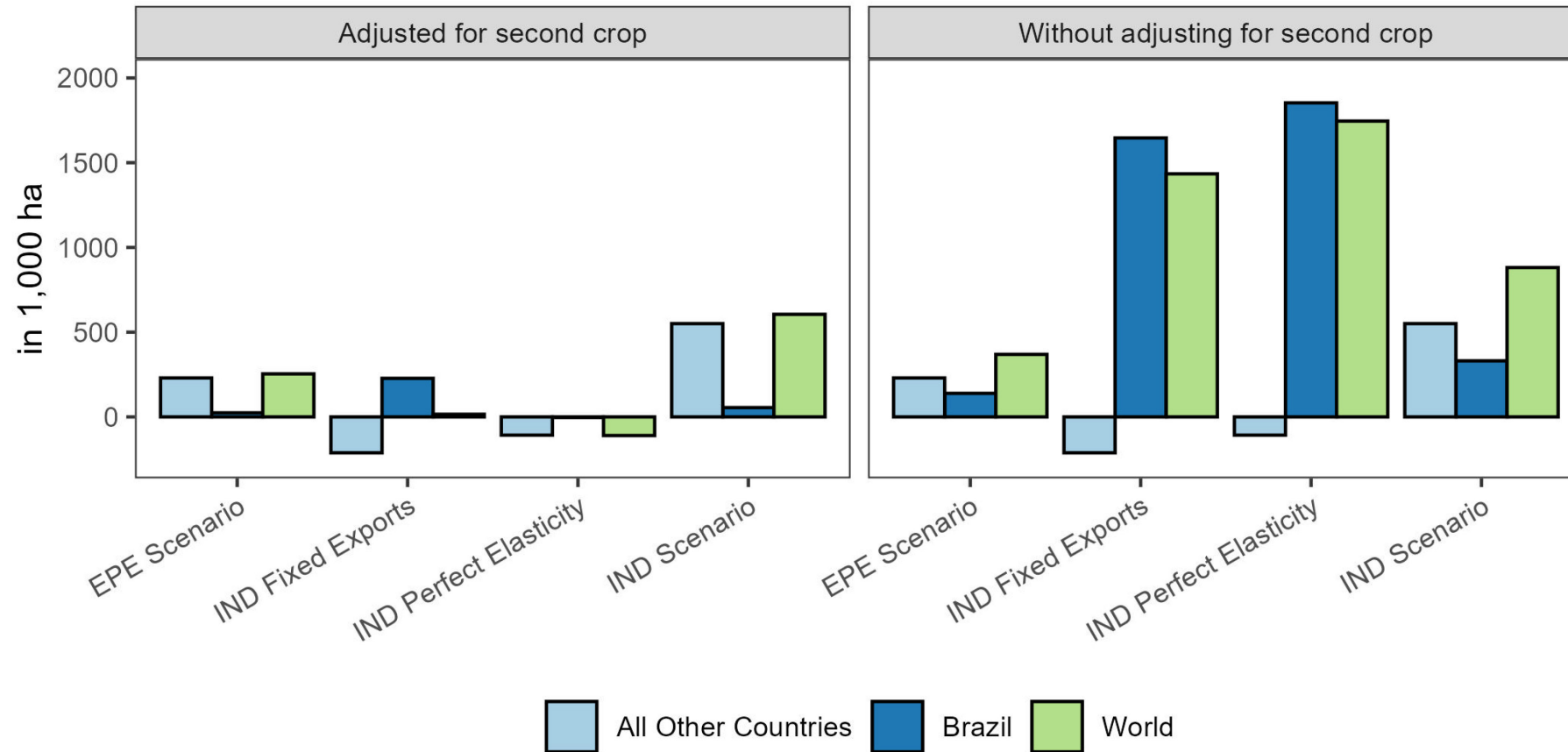
Theoretical Aspects of Scenarios

- Conditions for small net export changes and thus, small impact on international markets and land-use change
- Fixed Exports: Differentiation between domestic and international corn price
- Perfectly elastic supply (limiting case)
 - Pressure on domestic prices creating large reaction in domestic production with no reduction of exports
 - Land use changes due to indirect effects, i.e., availability of co-products displacing feed and affecting feed markets (e.g., soybean meal and soybeans)
 - Justification due to 17 million hectares currently fallowed for soybeans

Results: Change in Net Exports of Corn



Results: Area Change



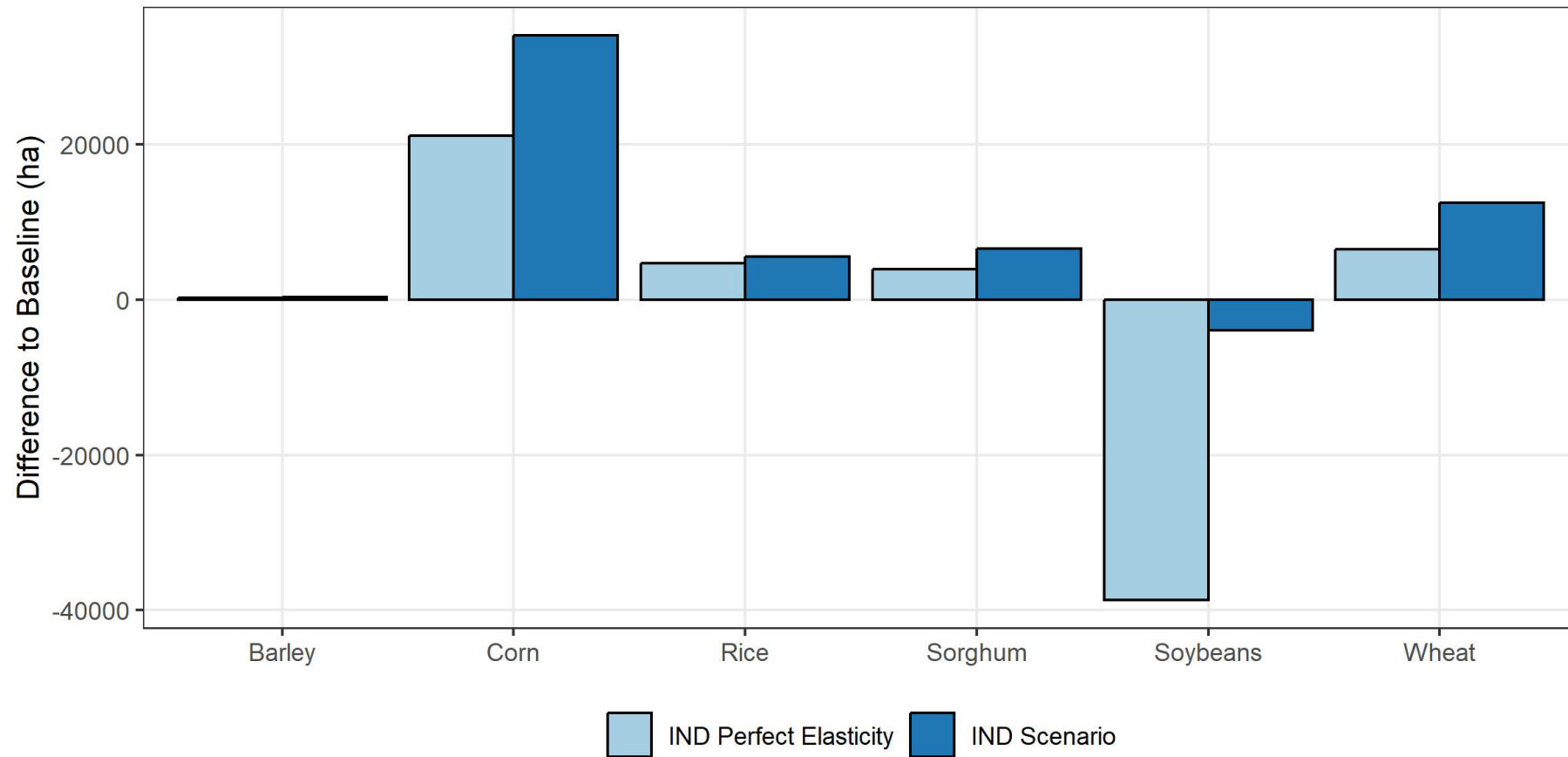
Area Effects: Summary

- Brazil
 - *IND Scenario*: Increase by 54,900 hectares (ha)
 - *IND Perfect Elasticity*: Decrease by 2,400 ha
- Global area change
 - *IND Scenario*: Increase by 605,300 ha
 - *IND Perfect Elasticity*: Decrease by 110,000 ha
- Corn price increase in *IND Scenario* drives expansion elsewhere
 - Corn area growth: EU (0.2%), Brazil (0.7%), Rest of World (0.3%)

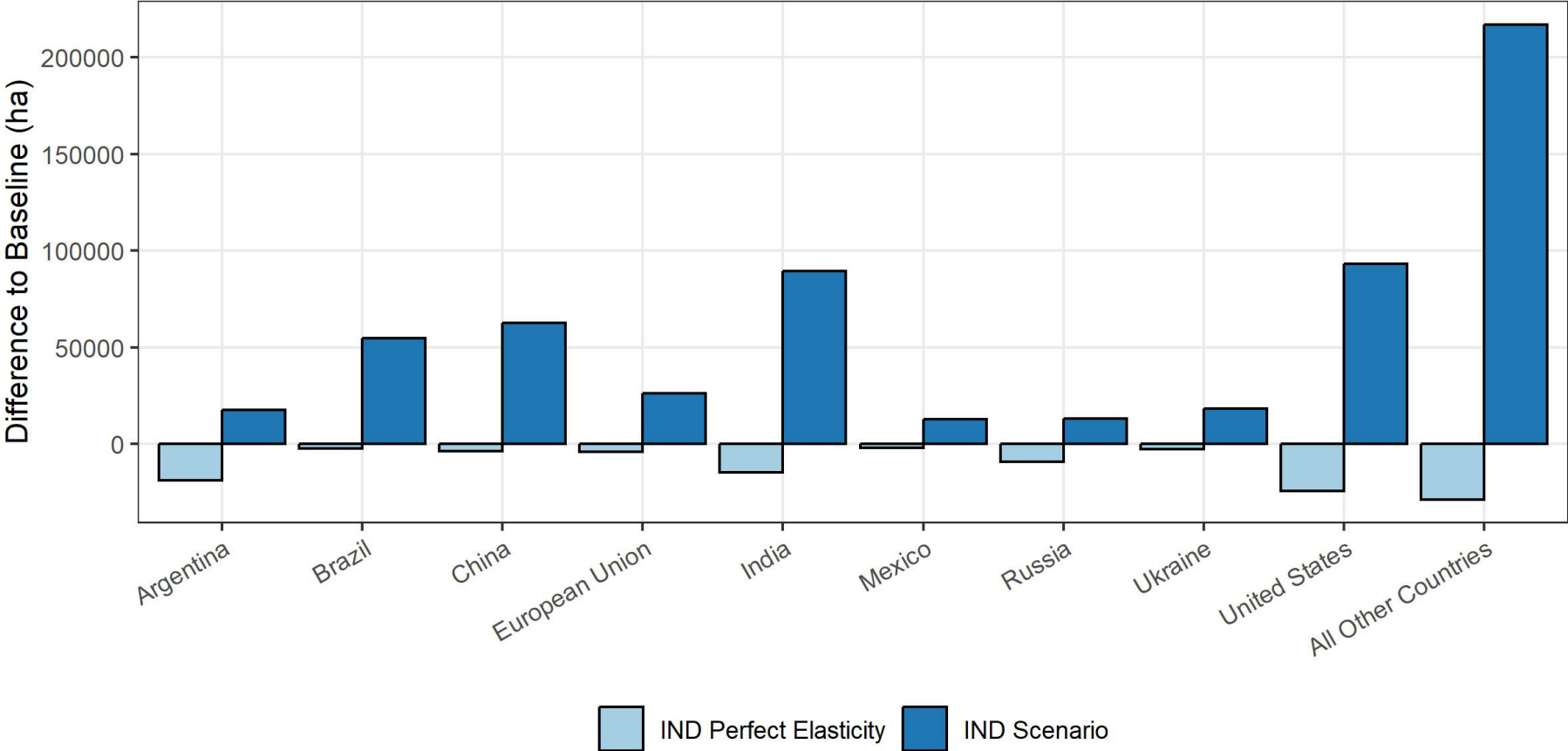
Land-Use Change and Biofuel Policy

- General concern of land-use change (LUC) emissions from biofuel policies
 - Emission range for U.S. corn ethanol (Searchinger et al., 2008; Dumortier et al., 2011; Carriquiry et al., 2020): 9.7–107 g CO₂-e MJ⁻¹
- Area harvested versus used in double-cropping scenarios
 - Increase in area harvested given second corn crop but no change in area used
- Area used as the driver for biomass and soil carbon emissions

Effects on Area Used: Brazil



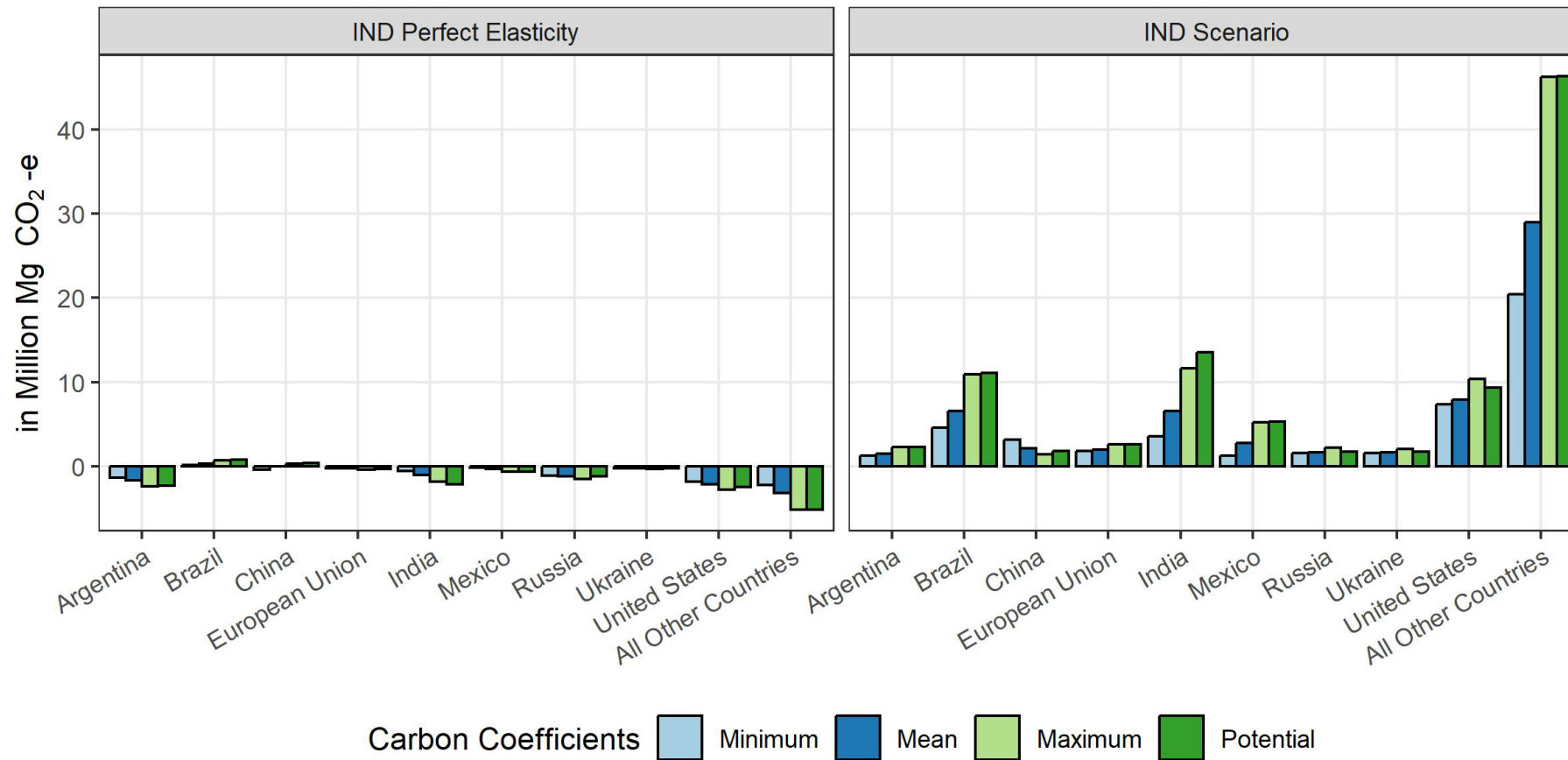
Area Effects: World



Land-Use Change Emissions I

- Emissions across minimum, mean, maximum, and potential carbon coefficients
 - *IND Scenario*: 46.5 to 95.6 million t CO₂-e
 - *IND Perfect Elasticity*: -8.0 to -13.4 million t CO₂-e
 - Mean changes: 61.7 and -9.8 million t CO₂-e for *IND Scenario* and *IND Perfect Elasticity*, respectively
- Corn area expands into high-carbon areas like Western/Central Africa
- Data source for Potential Coefficients: West et al. (2010)

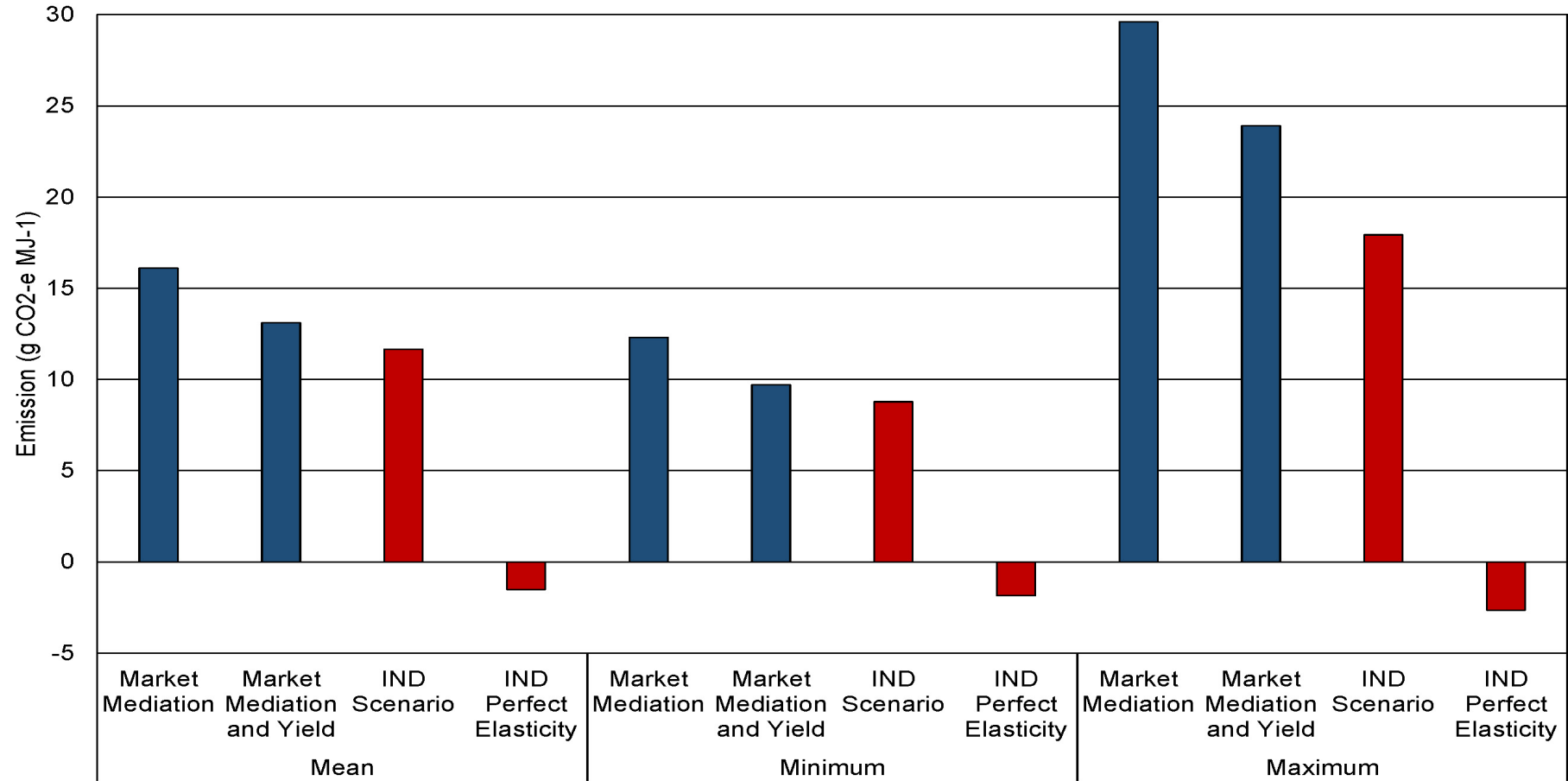
Land-Use Change Emissions II



Lifecycle Analysis (LCA) Results

- Approach following Carriquiry et al. (2020) and mean carbon coefficients
 - *IND Scenario*: 11.7 g CO₂-e MJ⁻¹
 - *IND Perfect Elasticity*: -1.9 g CO₂-e MJ⁻¹
 - U.S. corn ethanol: 13.1 to 16.1 g CO₂-e MJ⁻¹
- Double cropping changes global land area and emissions depending on (uncertain) elasticities and Brazil's capacity to expand second crop corn
 - Policies to control expansion into native vegetation and use of marginal lands
- Corn co-products displace soybean meal, reducing domestic/global prices and exports

LCA Results Comparison



Conclusion and Policy Implication

- Potential for large amounts of corn given double cropping in Brazil
- Analysis of conditions under which global market effects are minimized
- Alcohol-to-Jet (ATJ) pathway for production of SAF
 - Potential to qualify for SAF tax credit in the U.S.
 - Changing legislation and eligibility of foreign feedstocks
- Viable pathway for the difficult to decarbonize global aviation sector