Biofuels and Land Use: Empirical Evidence and GTAP Models

slides prepared for CARB Land Use Workshop

Steven Berry

Sterling Professor of Economics

Department of Economics, Yale University

Faculty Director, Tobin Center for Economic Policy

Outline

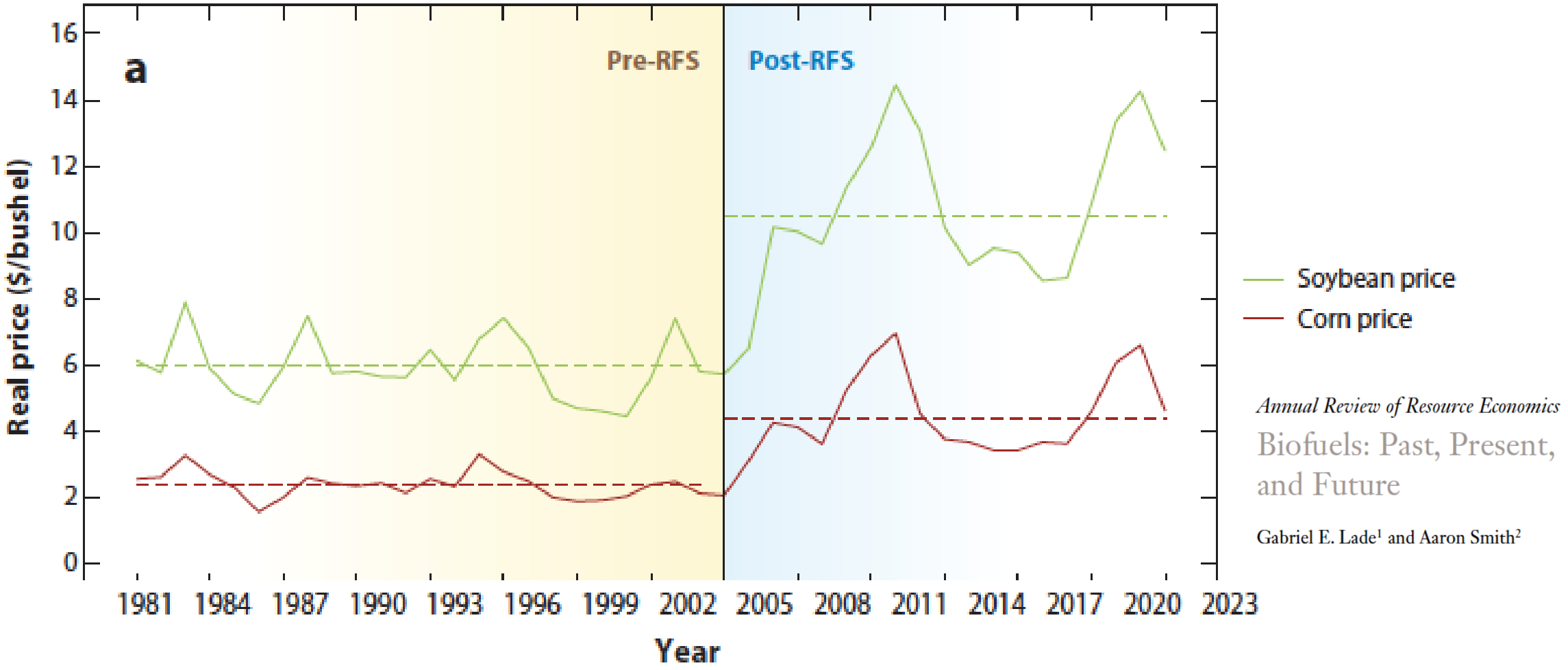
1. High-quality empirical evidence strongly indicates that biofuel mandates lead to tropical deforestation, contributing to climate change. Fossil fuels are likely better than biofuels.

    a) CARB mandates increase domestic prices for agricultural commodities
    b) These prices propagate internationally, raising returns to agriculture/beef in Brazil, etc
    c) The increase in returns to soy/beef/palm/etc leads directly to tropical deforestation

2. GTAP models predict otherwise because they lack a credible scientific basis for biofuel land use analysis (Berry, Searchinger, and Yang 2024). These models:

    a) use thousands of parameters and restrictive mathematical forms with no credible empirical basis
    b) assume unrealistically large declines in consumption
    c) incorrectly restrict international trade, by pure assumption
    d) use an economic land use model that predicts physically impossible results
    e) have no model of the conversion of unmanaged forest (much of the world's forests)
    f) make empirically unsupported assumptions of vast yield increases and low land-use responses
    g) make additional repeated ad-hoc adjustments to continually lower reported land use change

Biofuel mandates increase domestic prices for agricultural commodities



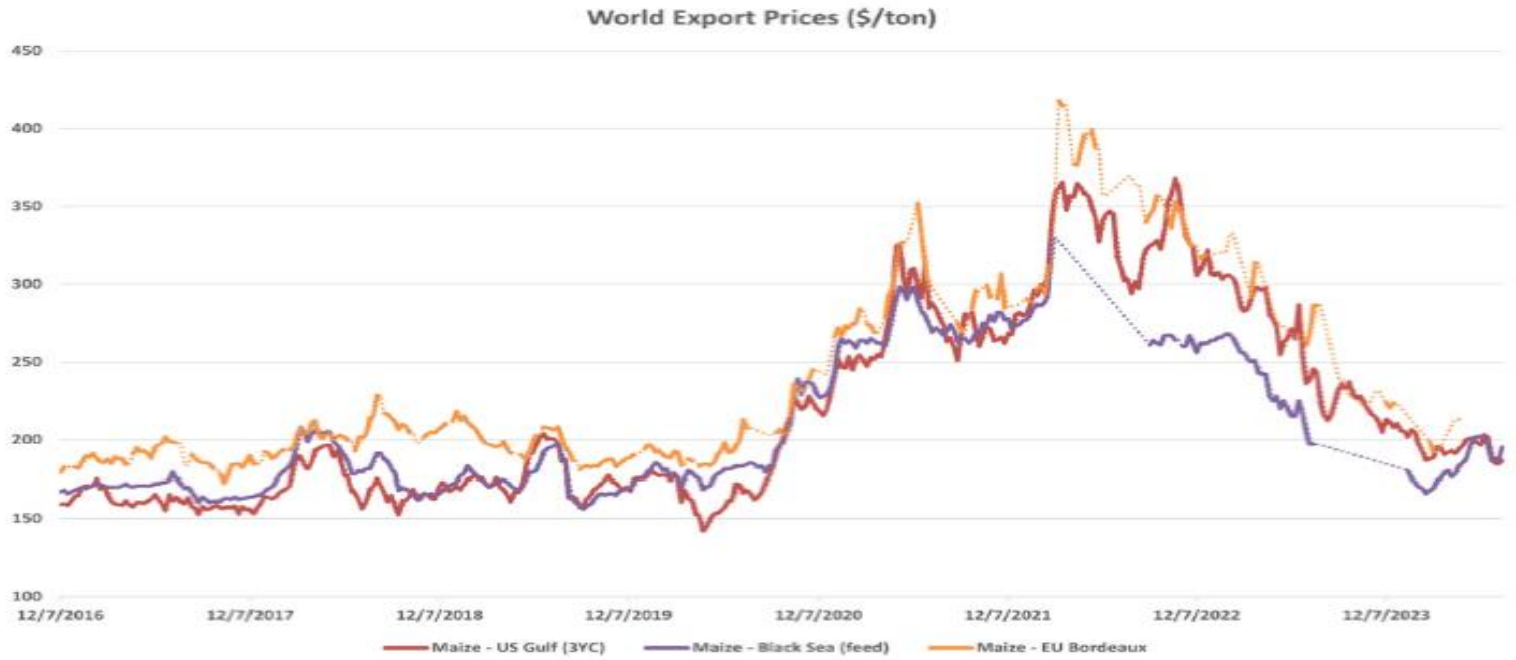
Annual Review of Resource Economics

Biofuels: Past, Present, and Future

Gabriel E. Lade[1] and Aaron Smith[2]

Price Shocks Propagate Internationally via the Arbitrage Activities of Large Trading Firms

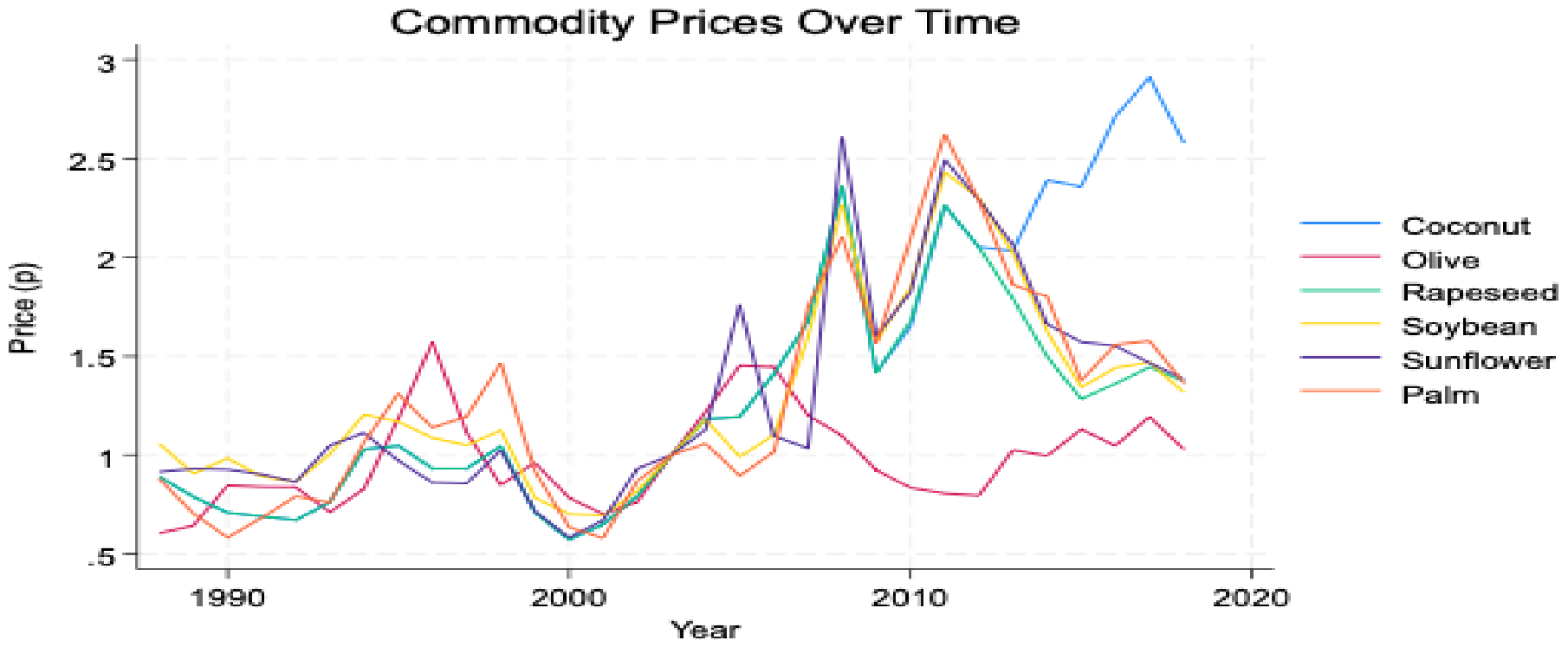
Figure F3: Correlation of world prices of maize from the U.S. (Gulf), the EU (Bordeaux), and the Black Sea (feed)



(Source: Authors' drawing based on data from the International Grains Council and FranceAgriMer)

For high-quality causal evidence: Roberts and Schlenker (2013)

An Increase in the Price of One Vegetable Oil will Increase the Price of Other Oils



For high-quality causal evidence: See Chen, Sexton,, and Smith (2025)

Tropical Deforestation is Highly Sensitive to Agricultural Returns

Using Vegetable Oils for Biofuel Accelerates Tropical Deforestation and Increases Carbon Emissions

Journal of the Association of Environmental and Resource Economists
Volume 7, Issue 1
January 2020
Pages 1-208

ARTICLE

Does Free Trade Increase Deforestation? The Effects of Regional Trade Agreements

View article page

Ryan Abman and Clark Lundberg

Tzu-Hui J. Chen[1], Richard J. Sexton[1], and Aaron Smith[2]

https://doi.org/10.1162/rest_a_01136 **Article history**

JOURNAL ARTICLE

Deforestation in the Amazon: A Unified Framework for Estimation and Policy Analysis

Eduardo Souza-Rodrigues

The Review of Economic Studies, Volume 86, Issue 6, November 2019, Pages 2713–2744,
https://doi.org/10.1093/restud/rdy070
Published: 06 December 2018 **Article history**

ELSEVIER
Journal of Development Economics
Volume 167, March 2024, 103217

Regular article

The deforestation effects of trade and agricultural productivity in Brazil ☆

Igor Carreira [a], Francisco Costa [b c], João Paulo Pessoa [d e]

No Credible Evidence that Yields will Greatly Increase with Crop Price Increases

- Economic theory predicts that yields will increase IF land use is held fixed
- Economic theory does NOT predict that yields will increase when land use can expand in response to price increases (yields could go up or down)
- Evidence on short-run price-driven yield increases shows effects ranging from slightly negative to slightly positive. Double-cropping did not increase as the GREET version of GTAP assumes.
- Long-run investments can favor higher yield (irrigation) or more land use (new forest roads)
- Long-run R&D can favor higher yields (GMO crops) or more land use (historical adaptation of soy agriculture to the tropics)

Summary of Empirical Evidence:

BIOFUEL MANDATES

➔increase domestic prices

➔which rise together with international prices

➔raising returns to tropical agriculture

➔ TROPICAL DEFORESTATION

GTAP models produce empirical predictions that differ from empirical reality

GTAP is a “computational model,” derived from the economic research of 40-50 years ago, not a modern microeconomic empirical model.

Many different models can fit a set of selected data points but have very different policy conclusions. Modern empirical applied microeconomics is focused on **credible** estimates of **cause-and-effect** (many “partial elasticities”) via appropriate econometric methods.

GTAP employs thousands of parameters and restrictive mathematical forms with little credible empirical basis

- Many parameters are chosen without any stated empirical evidence; there is no comprehensive catalog of parameters with supporting evidence.
- Too often, supply and demand parameters are set equal without evidence.
- When there is a stated empirical basis, that evidence typically falls far short of the modern standard for credibility (see J. Angrist, Nobel Prize). In some key cases, evidence is badly misinterpreted to favor biofuels.
- Many key predictions ("diversion ratios") are determined without data but by mathematical forms that are chosen purely for convenience.
- **These points alone are enough to conclude that the model provides no credible scientific basis for the study of biofuels and land use.**

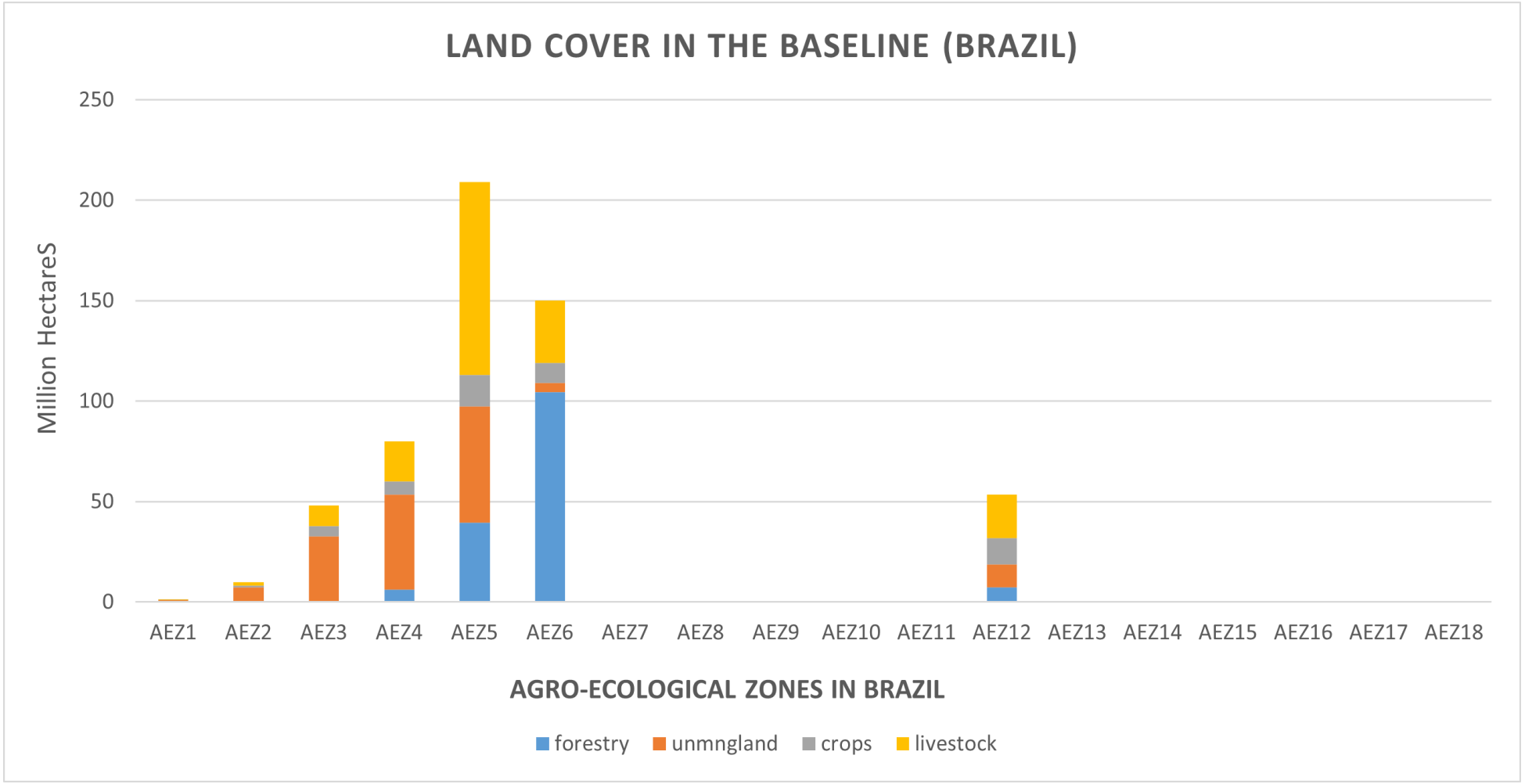
GTAP's economic land model does not respect physical reality. A hand-of-God adjustment then re-creates forests

GTAP-BIO Predictions of CO_2 Emissions from U.S. Forest Land Use Change due to Ethanol Mandate
Non-Market Ad-hoc Adjustment vs Economic Predictions

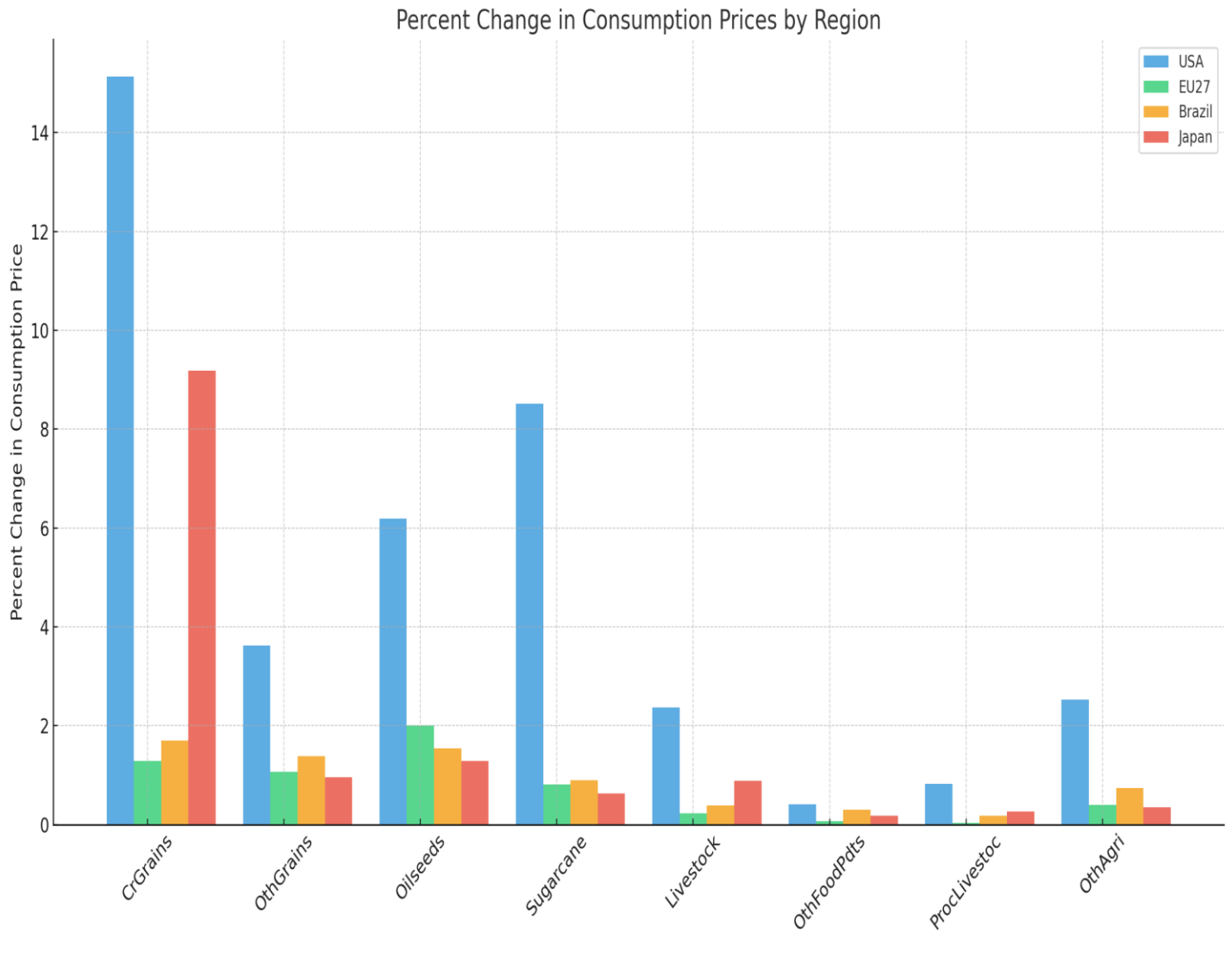
	Economic Prediction	After *Ad Hoc* Adjustment
AEZ7	141.61	−5.74
AEZ8	375.99	−5.22
AEZ9	331.58	3.77
AEZ10	2386.75	194.05
AEZ11	1708.66	154.42
AEZ12	931.92	118.33
AEZ13	141.43	−4.96
AEZ14	571.93	−1.54
AEZ15	514.30	−0.06
AEZ16	3.61	0.02
Total	7107.79	453.07

Note: The values in the table are presented in million Mg CO_2 Emissions. Agricultural zones AEZ1 through AEZ6, and AEZ17 and AEZ18 are excluded due to zero land cover shares in the model. Source: Berry, Searchinger, Yang (2024).

In GTAP, unmanaged land (forest) cannot be converted



GTAP Shuts Down International Trade by Assuming a Large "Home Preference" for Crops



Conclusions

One goal of today's discussion is "***to consider how best to mitigate any risks of harmful land use impacts or food market conflicts identified, for consideration in a future LCFS update.***"

Empirical evidence on land use and food prices was largely lacking in the early days of biofuel mandates. But in more recent years, a high-quality empirical literature shows that biofuel mandates lead to tropical deforestation and higher carbon emissions, while raising the cost of living through higher prices for food and fuel.

Future LCFS updates should heavily weigh this (and future) evidence. In light of evidence, mandated levels should be greatly reduced, or at the very least held fixed.