Making the market: How US policy affects agricultural and biofuel production and profitability under technology adoption

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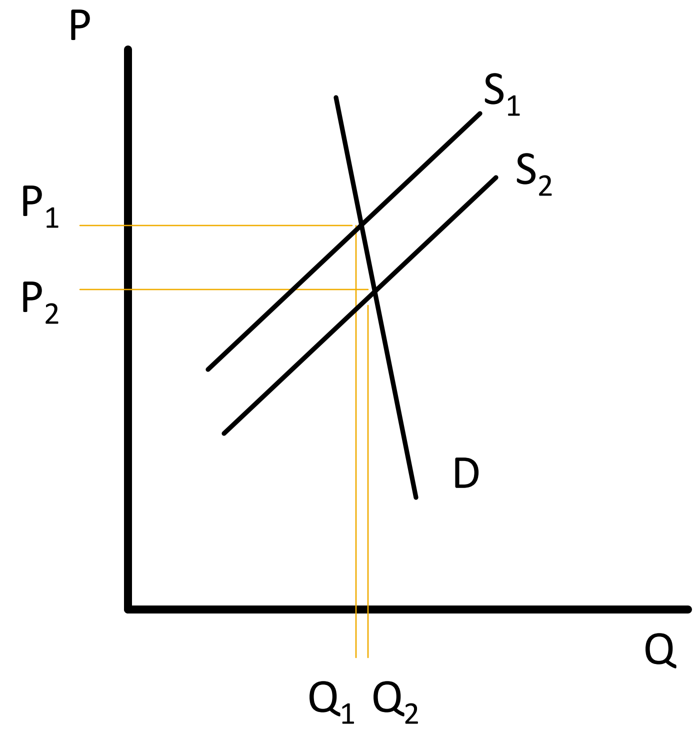
Agenda

- Cochrane's treadmill
- US biofuel policy and markets
- Stochastic impacts of scenarios
  - Increase in US maize yields
  - Increase in ethanol extracted from each ton of maize in dry mill plants
  - Increase in ethanol extracted from each ton of all feedstocks in all major types of plants (not discussed in presentation, but included in paper)

Cochrane's treadmill

- Productivity gains shift out supply curve
- In face of inelastic demand for food, benefits go mostly to consumers
- Is this still true given biofuel policies and markets?

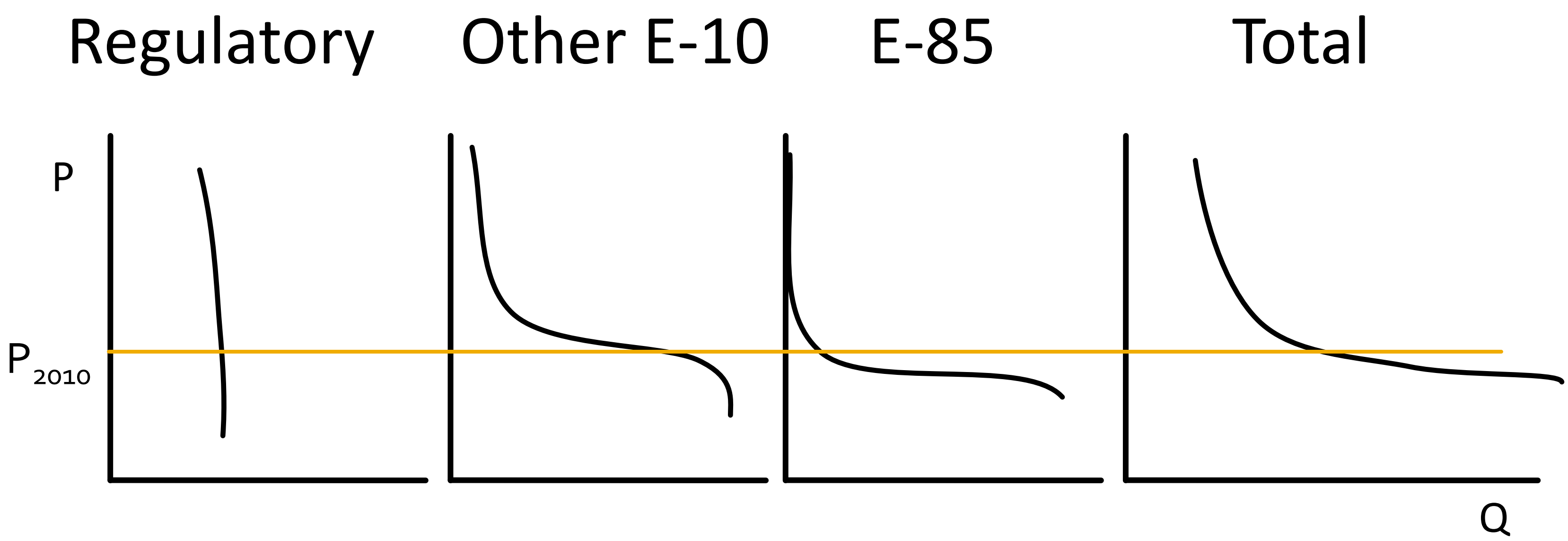


Key elements of US biofuel policy

tax credits	ethanol tariffs	Renewable Fuel Standard
• Given to fuel blenders per gallon blended	• Specific tariff on imports from most countries	• Minimum levels of biofuel use by class

Renewable Identification Numbers (RINs) are used to ensure compliance with the RFS. Obligated parties get required RINs by using biofuels or by buying RINs from others who have used biofuels in excess of their obligations.

Ethanol demand



Regulatory: 1/3 of US gasoline has to be blended with oxygenate to meet clean air requirements, and ethanol is almost only alternative

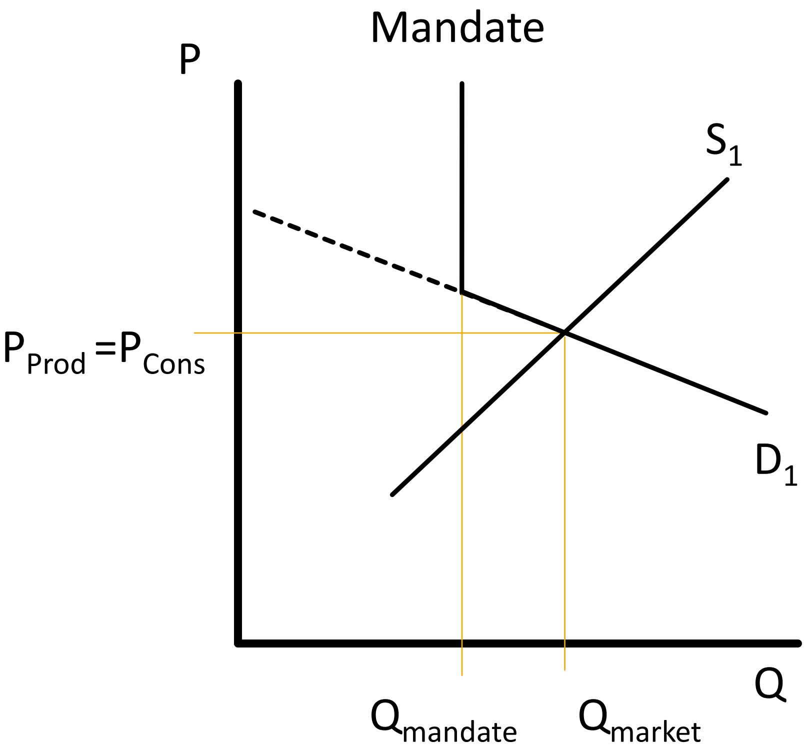
E-10: In other markets, consumers can choose to buy 10% ethanol blends

E-85: Some consumers can use E-85 (if they have flex fuel vehicle and can find a service station that sells it)

Total: Total ethanol demand is sum of parts. Figure implicitly depicts longer-run. Short run is less elastic (e.g., E-85 infrastructure constraints)

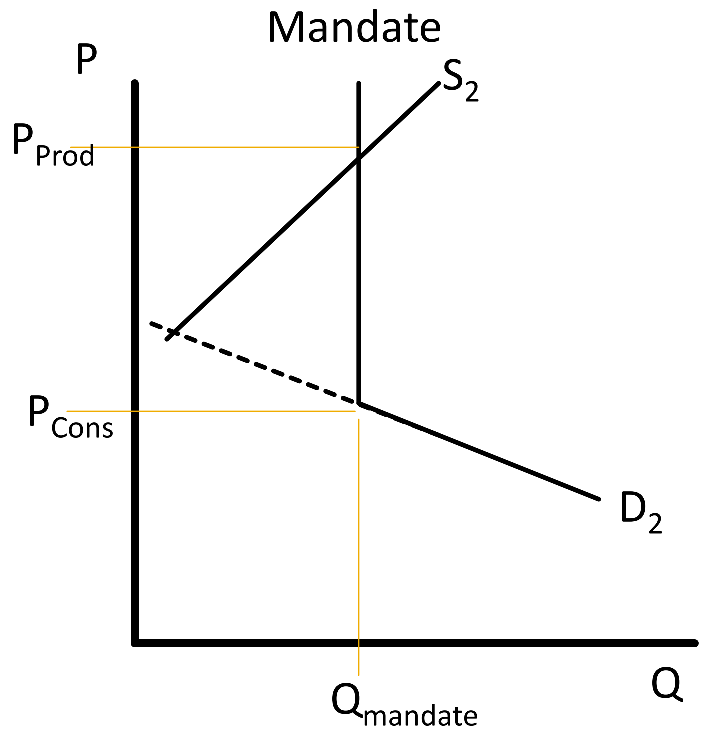
Use mandates, prices and RIN values in the ethanol market

Mandate not binding



RIN value = 0 (or nearly 0)

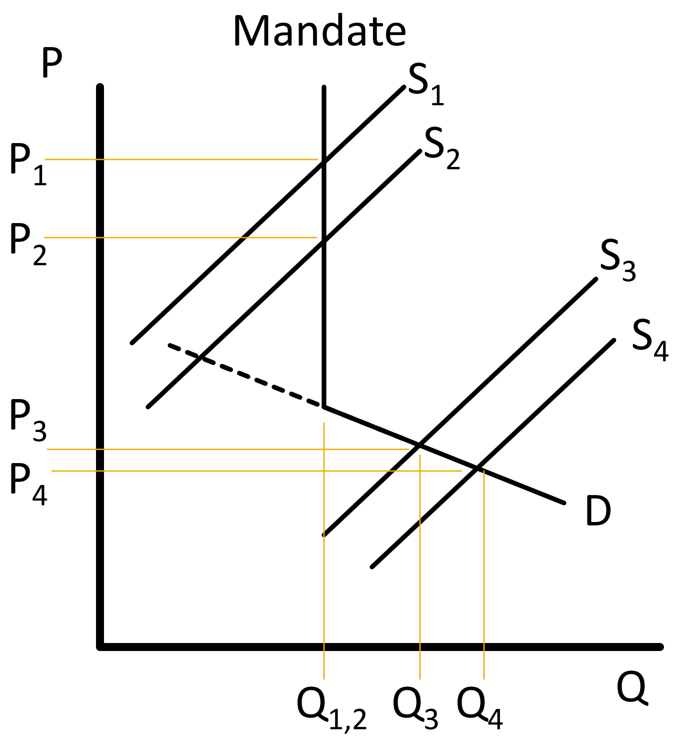
Mandate binding



RIN value = $P_{Prod} - P_{Cons}$

Note: For exposition, diagrams ignore other wedges between producer and consumer prices, including the blender's credit, taxes, and marketing costs, which are included in the model.

Yield gain in corn markets *or* efficiency gains in biofuels markets



P: Price of corn or ethanol

S: Supply of corn or ethanol

D: Demand for ethanol or for corn to make ethanol

Price and quantity effects of similar supply shifts are very different when mandates are or are not binding

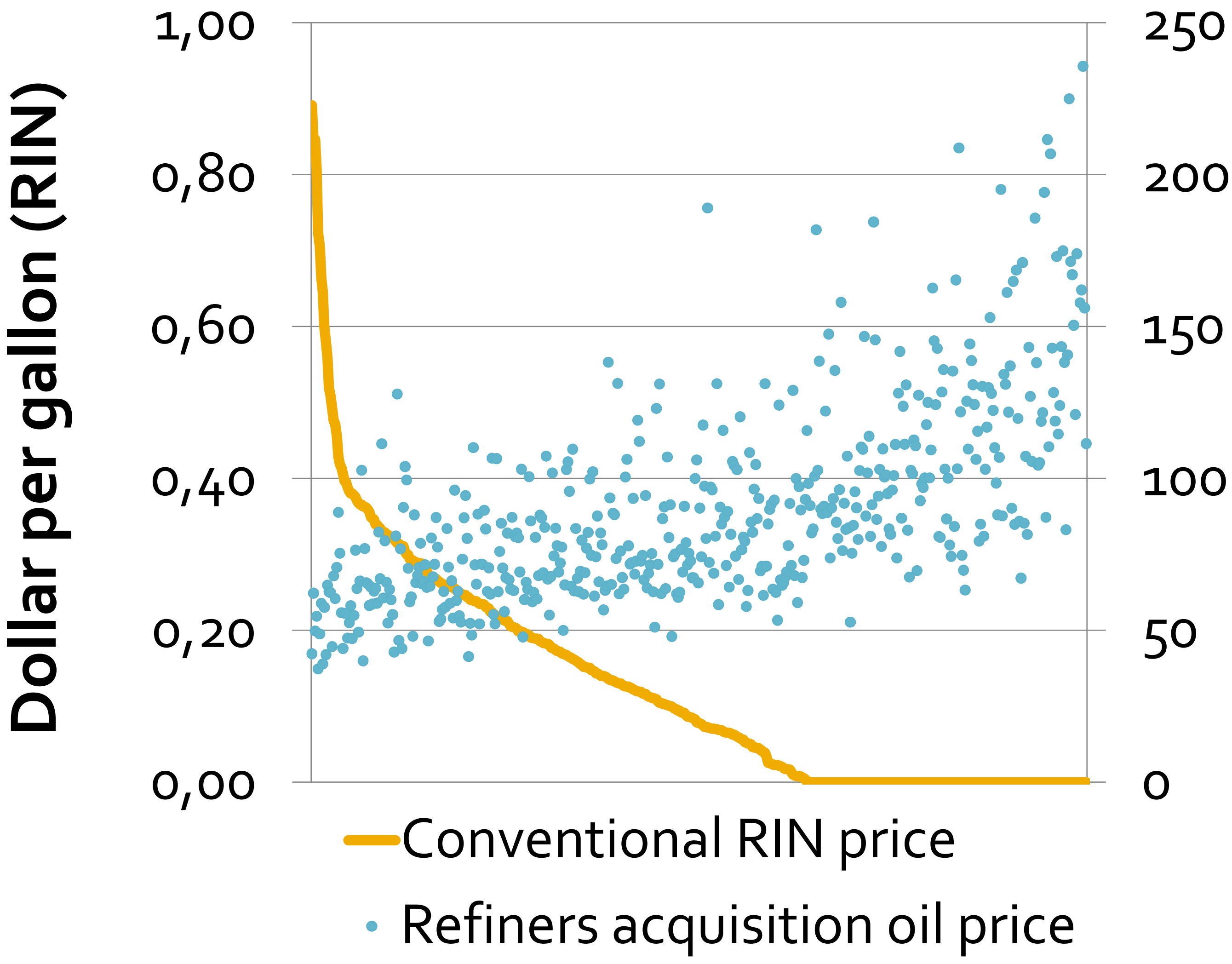
Stochastic model, part 1

- Outgrowth of FAPRI model developed over last 25 years
- US partial equilibrium model
  - Rest of world represented with reduced form equations
  - Aligned to global FAPRI deterministic baseline
  - Covers crop, livestock, biofuel markets
- Dynamic
  - Solves for next 10 years
  - Includes investment behavior (e.g., livestock, biofuel capacity)
- Hybrid
  - Some parameters estimated econometrically
  - Others based on analyst judgment, but calibrated to market data and reviewed frequently

Stochastic model, part 2

- Exogenous variables drawn from grouped joint distributions
  - Crop yield error terms (equations include trend & prices)
  - Energy prices and input costs
  - Domestic demand equation error terms
  - Stock demand equation error terms
  - Export error terms (prices in reduced-form equations)
- 500 sets of correlated draws are created and model solved for each set
  - Model must be robust enough to give 500 "plausible" solutions for 1500 variables for 10 years
  - Results are saved so it is possible to analyze each of the 500 solutions

Petroleum price sorted by 2015 conventional RIN price



Note: Chart cuts off two outcomes with oil prices in excess of $250/barrel and RIN = 0

What determines whether biofuel use is likely to exceed mandate (3 examples)

- Oil prices
  - Higher oil prices mean higher gasoline and diesel prices, mean more demand for biofuels, means biofuel consumption may exceed mandate
- Maize production
  - Higher maize production mean lower maize prices, mean ethanol production is more profitable, means more ethanol production, means lower ethanol prices, mean consumption may exceed mandate
- Maize export demand
  - Lower maize export demand means lower maize prices, mean ethanol production is more profitable…
- Different combinations possible
  - Can have high oil price, but mandate may be binding if a drought reduces maize yields or export demand is strong
  - Can have low oil price, but mandate may not be binding if bumper maize production and weak export demand

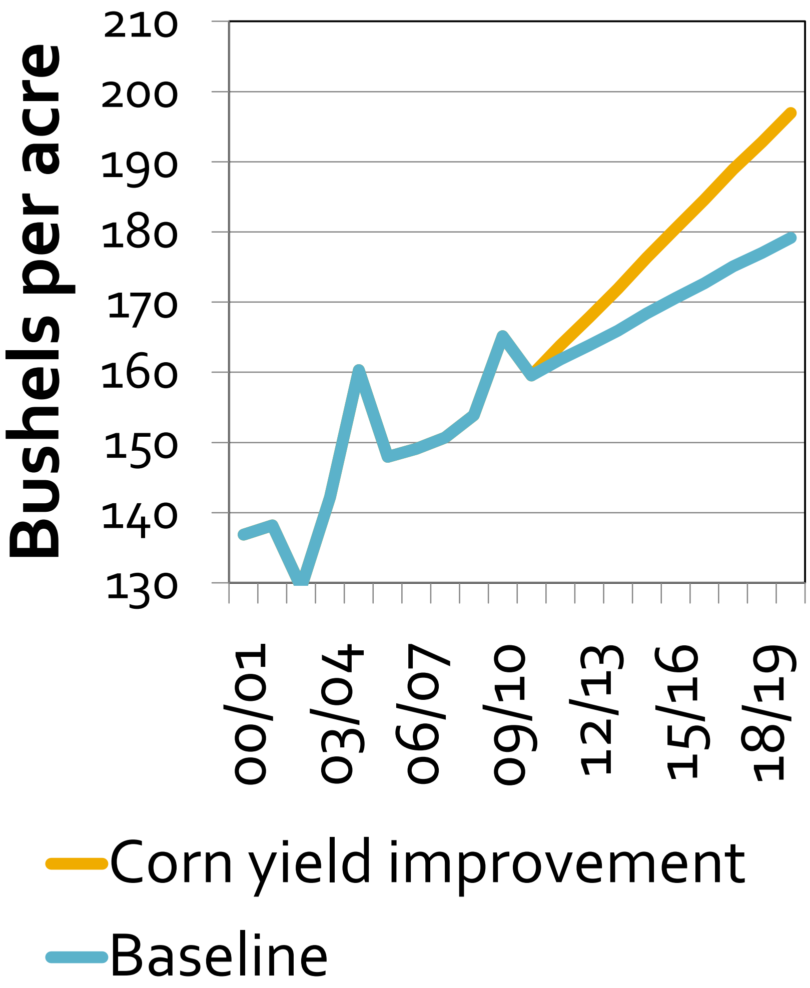
Baseline assumptions

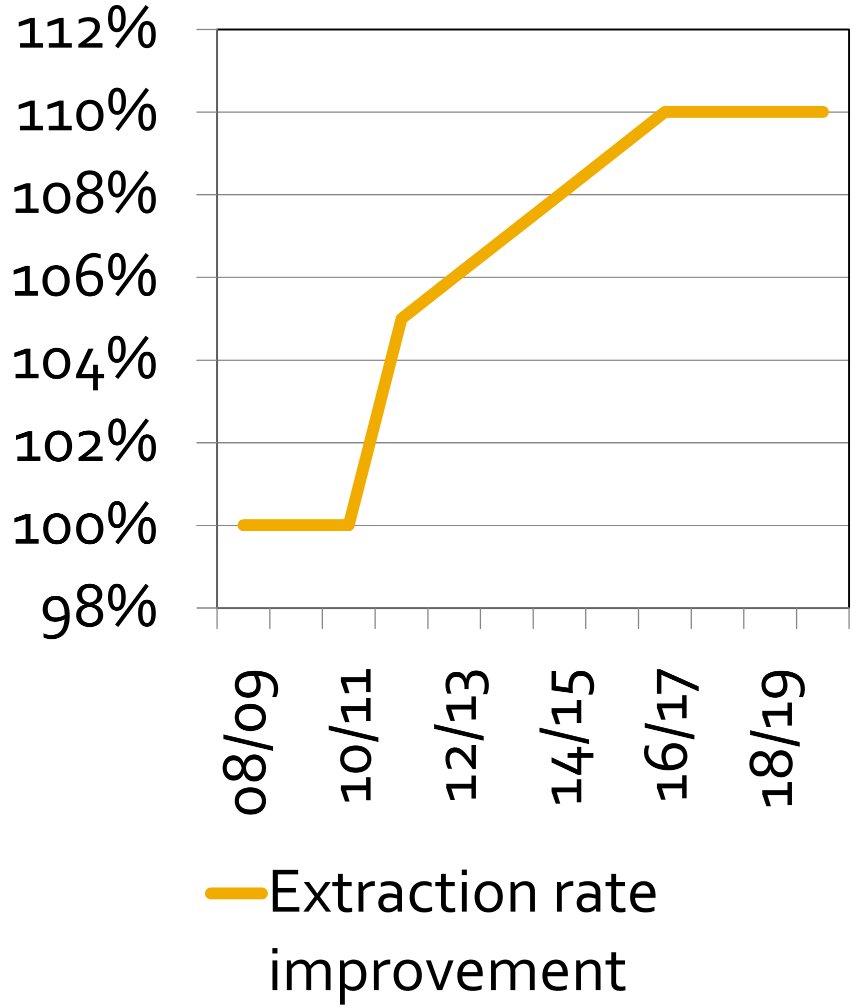
- Assumes extension of current policies
  - Includes use mandates, tax credits and tariffs
  - As well as current US farm programs

- Technology grows in line with past trends

- Macro-economy evolves as forecast by IHS Global Insight
  - Moderate global economic recovery
  - Avg. oil price rises to around $100/barrel by 2018

Technology scenarios





Effects of increasing maize yields

(2015-19 average of 500 stochastic outcomes)

	Absolute change from baseline	Percentage change from baseline
Maize yield (tons per ha)	0.87	7.9%
Maize production (mt)	24.50	6.5%
Maize price ($ per ton)	-17.61	-11.2%
Maize used for ethanol (mt)	6.62	4.6%
Maize used for feed (mt)	7.40	5.4%
Maize exports (mt)	9.28	16.0%
Ethanol production (bil. liters)	3.08	4.5%
Ethanol consumption (bil. liters)	2.88	3.9%
Ethanol producer price (cents/liter)	-1.69	-3.2%
Ethanol consumer price (cents/liter)	-0.57	-1.0%
RIN value (cents/liter)	-1.23	-45.2%

Effects of increasing maize yields
(2015-19 average changes from baseline)

	Top quintile of baseline RIN values (mandate is binding)	Bottom quintile of baseline RIN values (not binding)
Maize yield (tons per ha)	0.87	0.87
Maize production (mt)	21.97	27.11
Maize price ($ per ton)	-19.22	-16.70
Maize used for ethanol (mt)	**2.10**	**10.37**
Maize used for feed (mt)	8.52	6.70
Maize exports (mt)	9.98	9.01
Ethanol production (bil. liters)	1.33	4.58
Ethanol consumption (bil. liters)	1.13	4.37
Ethanol producer price (cents/liter)	**-3.08**	**-0.73**
Ethanol consumer price (cents/liter)	-0.39	-0.73
RIN value (cents/liter)	-2.95	0.00

Key results for maize and ethanol markets from the higher maize yield case

- When mandates are binding
  - Ethanol production changes very little
  - Effects on corn and ethanol producer prices are relatively large (large portion of demand is very inelastic)
  - Ethanol producer prices fall more than consumer prices, as cost of compliance with RFS (RIN values) falls
- When mandates are not binding
  - Ethanol use of corn increases more than corn exports
  - Effects on corn and ethanol producer prices are much smaller (demand is more elastic)
  - Changes in consumer and producer prices of ethanol are the same (RIN value = 0 in both cases)

Other effects of higher maize yields
(2015-19 average of 500 stochastic outcomes)

	Absolute change from baseline	Percentage change from baseline
Area used for major crops (mil. ha)	-0.63	-0.5%
Wheat price ($ per ton)	-12.16	-6.4%
Soybean price ($ per ton)	-12.01	-3.2%
Net farm income (bil. $)	-2.74	-3.4%
Consumer food expenditures (bil $)	-3.12	-0.2%
RFS compliance costs (bil $)	-0.60	-12.4%
Biofuel tax credit costs (bil. $)	0.39	3.6%
Farm program costs (bil. $)	0.16	1.6%

Note: The aggregate measures (net farm income, food expenditures, etc.) are not welfare measures, but they are indicators of interest to policy makers.

Other effects of higher maize yields
(2015-19 average changes from baseline)

	Top quintile of baseline RIN values (mandate is binding)	Bottom quintile of baseline RIN values (not binding)
Area used for major crops (mil. ha)	-0.67	-0.60
Wheat price ($ per ton)	-13.45	-11.40
Soybean price ($ per ton)	-13.78	-10.77
Net farm income (bil. $)	-3.25	-2.40
Consumer food expenditures (bil $)	-3.37	-3.00
RFS compliance costs (bil $)	-1.52	0.07
Biofuel tax credit costs (bil. $)	0.21	0.55
Farm program costs (bil. $)	0.19	0.13

Note: The aggregate measures (net farm income, food expenditures, etc.) are not welfare measures, but they are indicators of interest to policy makers.

Key results for other indicators from the higher maize yield case

- In general
  - Cross-commodity effects are important—wheat and soybean prices fall even without change in their yields
  - Farm income falls, as effects of lower crop prices offset increased crop production, improved livestock profitability
  - Consumer food expenditures fall in nominal dollars
  - Farm program cost impacts are small—prices are too high to trigger price-based subsidies very often
- Effects that depend on whether mandates are binding
  - Reduction in RFS compliance costs to fuel consumers are substantial when mandates are binding
  - Negative effect on farm income is greater when mandates are binding (demand is more inelastic)
  - Biofuel tax credit costs to taxpayers are greater when mandates are not binding (consumption increases)

Effects of increasing ethanol yields per ton of maize in dry mill ethanol plants
(2015-19 average of 500 stochastic outcomes)

	Absolute change from baseline	Percentage change from baseline
Ethanol yield (liters per ton of maize)	41.71	9.8%
Ethanol production (bil. liters)	4.15	6.1%
From maize	4.35	7.1%
From other feedstocks	-0.21	-3.4%
Ethanol consumption (bil. liters)	3.99	5.3%
Ethanol producer price (cents/liter)	-1.83	-3.5%
Ethanol consumer price (cents/liter)	-0.46	-0.8%
RIN value (cents/liter)	-1.52	-55.8%
Maize used for ethanol (mt)	-2.81	-1.9%
Maize used for feed (mt)	4.36	3.2%
Maize price ($ per ton)	1.40	0.9%

Effects of increasing ethanol yields per ton of maize in dry mill ethanol plants
(2015-19 average changes from baseline)

	Top quintile of baseline RIN values (mandate is binding)	Bottom quintile of Baseilne RIN values (not binding)
Ethanol yield (liters per ton of maize)	41.71	41.71
Ethanol production (bil. liters)	0.88	7.30
From maize	0.94	7.67
From other feedstocks	-0.06	-0.37
Ethanol consumption (bil. liters)	0.70	7.13
Ethanol producer price (cents/liter)	-3.55	-0.81
Ethanol consumer price (cents/liter)	-0.16	-0.81
RIN value (cents/liter)	-3.77	0.00
Maize used for ethanol (mt)	**-9.05**	**2.19**
Maize used for feed (mt)	5.47	3.78
Maize price ($ per ton)	**-1.63**	**4.18**

Key results for maize and ethanol markets from the higher dry mill ethanol yield case

- When mandates are binding
  - Ethanol production changes very little
  - With higher ethanol yields, less corn is needed to produce quantity required to satisfy RFS
  - So corn prices fall
- When mandates are not binding
  - Ethanol production increases sharply
  - Increase in ethanol yield more than outweighs lower ethanol producer price, so more tons of corn are used by ethanol plants
  - So corn prices rise

Other effects of higher dry mill ethanol yields
(2015-19 average changes from baseline)

	Top quintile of baseline RIN values (mandate is binding)	Bottom quintile of baseline RIN values (not binding)
Net farm income (bil. $)	**-0.44**	**1.38**
Consumer food expenditures (bil $)	**-0.06**	**1.04**
RFS compliance costs (bil $)	-2.17	0.00
Biofuel tax credit costs (bil. $)	0.10	0.81
Farm program costs (bil. $)	0.02	-0.05

Note: The aggregate measures (net farm income, food expenditures, etc.) are not welfare measures, but they are indicators of interest to policy makers.

Some lessons

- Given mix of US biofuel policies, baselines matter a lot
- Magnitudes of effects of technology shocks are very different depending on whether biofuel mandates are binding
- In some cases, even the direction of the effects can change
- One reason stochastic analysis has value—at a minimum, need to do sensitivity analysis

Implications for EU experience

- Policies are very different, so not directly parallel
- BUT…
  - No strict limit on 1st generation biofuels
  - Limits on blends of particular biofuels
  - Discretion in mix of ethanol/biodiesel to achieve overall target
- All this suggests “correct” modeling may be every bit as complicated as in US case
  - May not be sufficient to assume fixed quantities or shares for ethanol or biodiesel, especially not by feedstock
  - Sure glad it’s not my problem

THANKS!

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- FAPRI-Missouri website: www.fapri.missouri.edu
- And, in a shameless plug completely unrelated to this presentation, buy my new book published by FT Press, *The Economics of Food: How Feeding and Fueling the Planet Affects Food Prices*