

Renewable Fuel Standard: A historical evaluation of economic impacts using partial and general equilibrium models

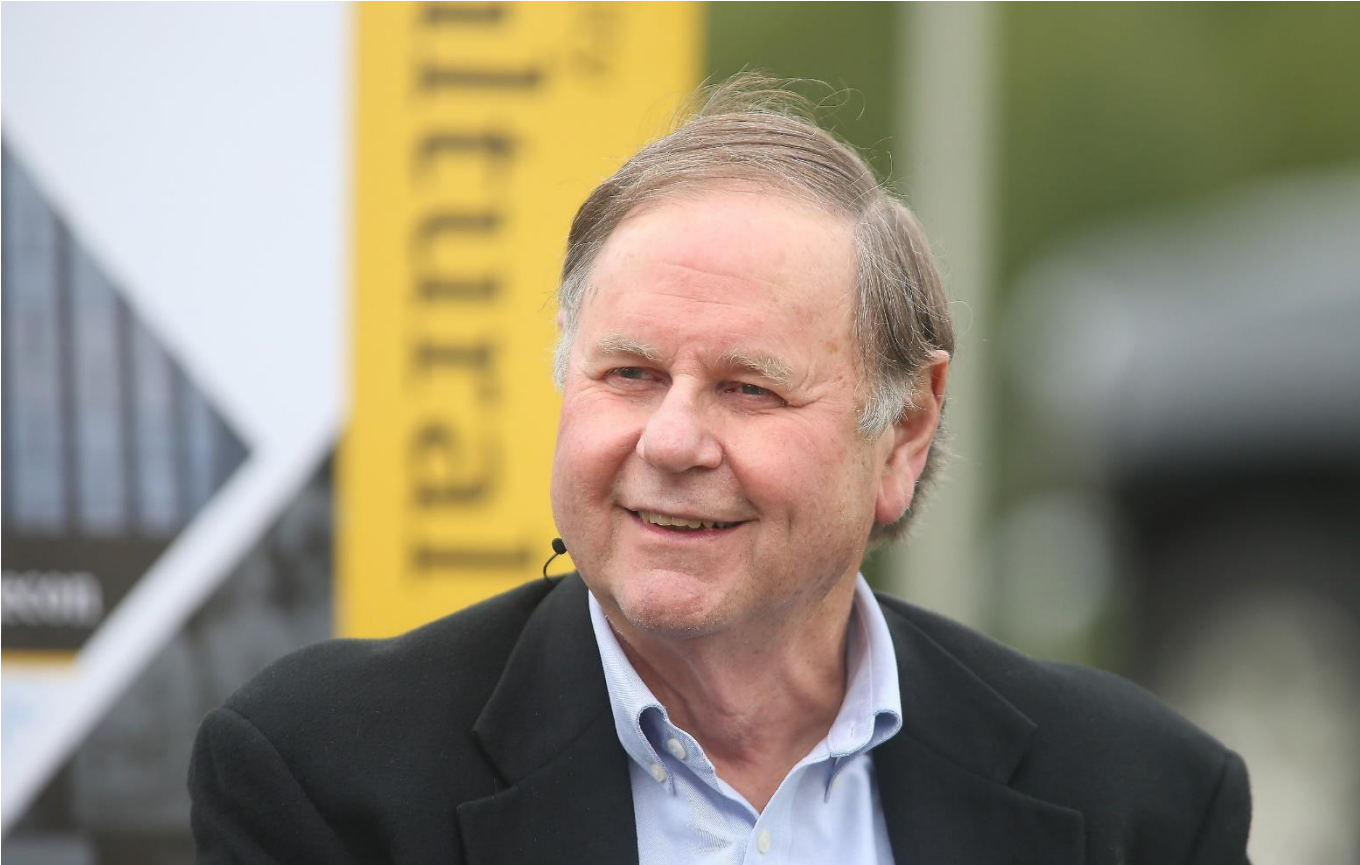
Presented by Farzad Taheripour

Based on a joint research with Harry Baumes and Wallace E. Tyner

**Department of Agricultural Economics
Purdue University**

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In Memory of Late Professor Wallace E. Tyner



After 10 month of Wally's passing, it is still profoundly hard to believe that he is no longer with us.

Wally and I worked very closely for many years. We jointly developed many research programs, published many papers, and went to many conferences and meetings.

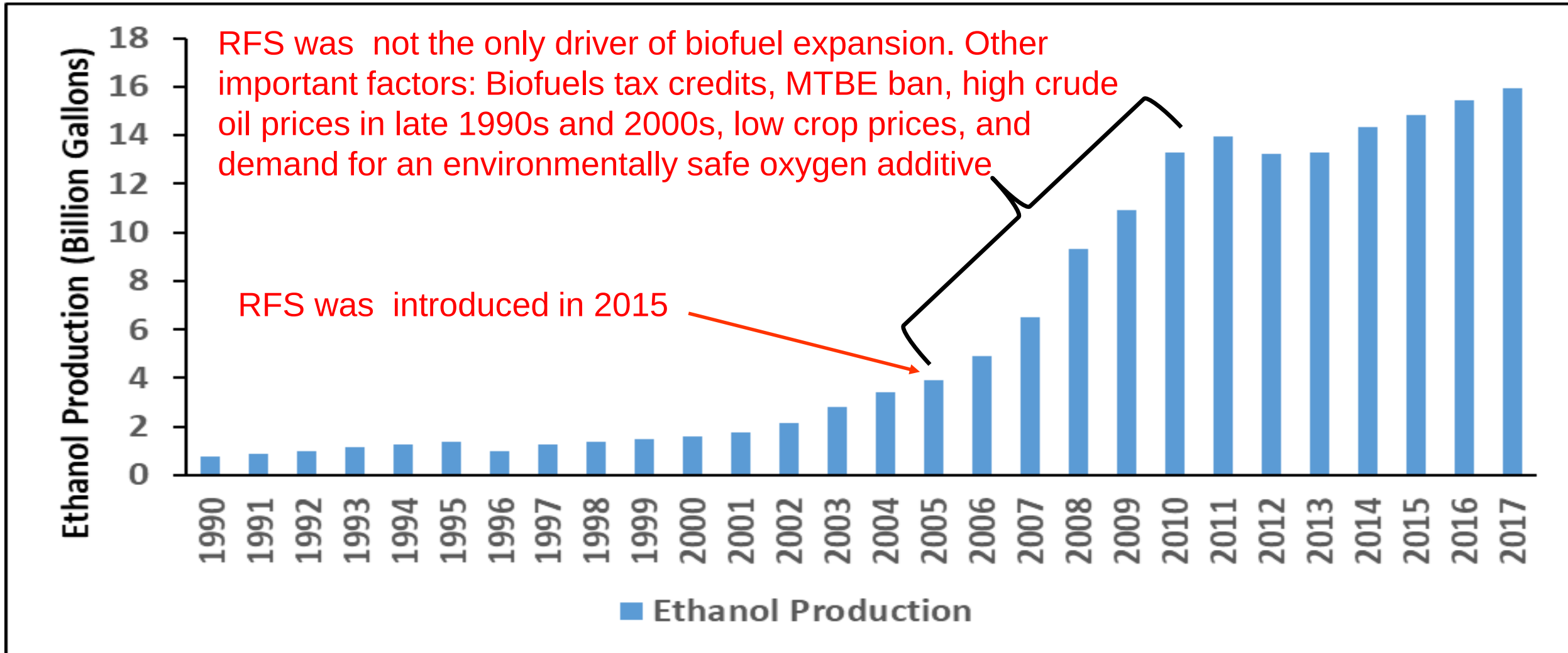
What I present today, is the last piece of work we developed together.

Wally is no longer with us, but he will remain in our hearts and minds for ever.

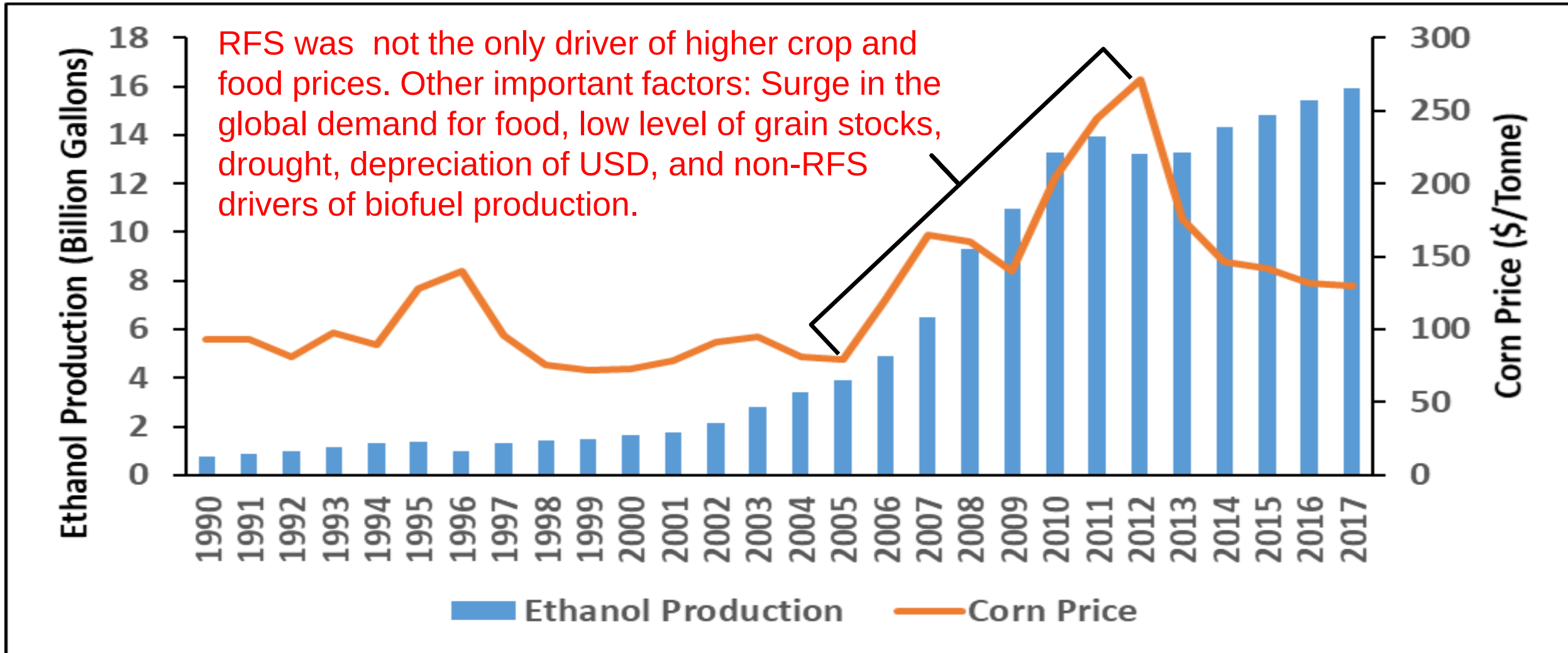
Introduction: Background of Renewable Fuel Standard (RFS)

- The US RFS has been implemented since 2005 to encourage consumption of biofuels for several reasons including but not limited to:
 - Reduce GHG emissions,
 - Improve energy security,
 - Enhance income and employment in rural areas.
- The RFS has played a critical role in providing a secure environment to produce and consume more biofuels since its implementation.
- However, it was not the only factor that encouraged the biofuel industry to grow.

Introduction: Role of RFS in biofuel expansion



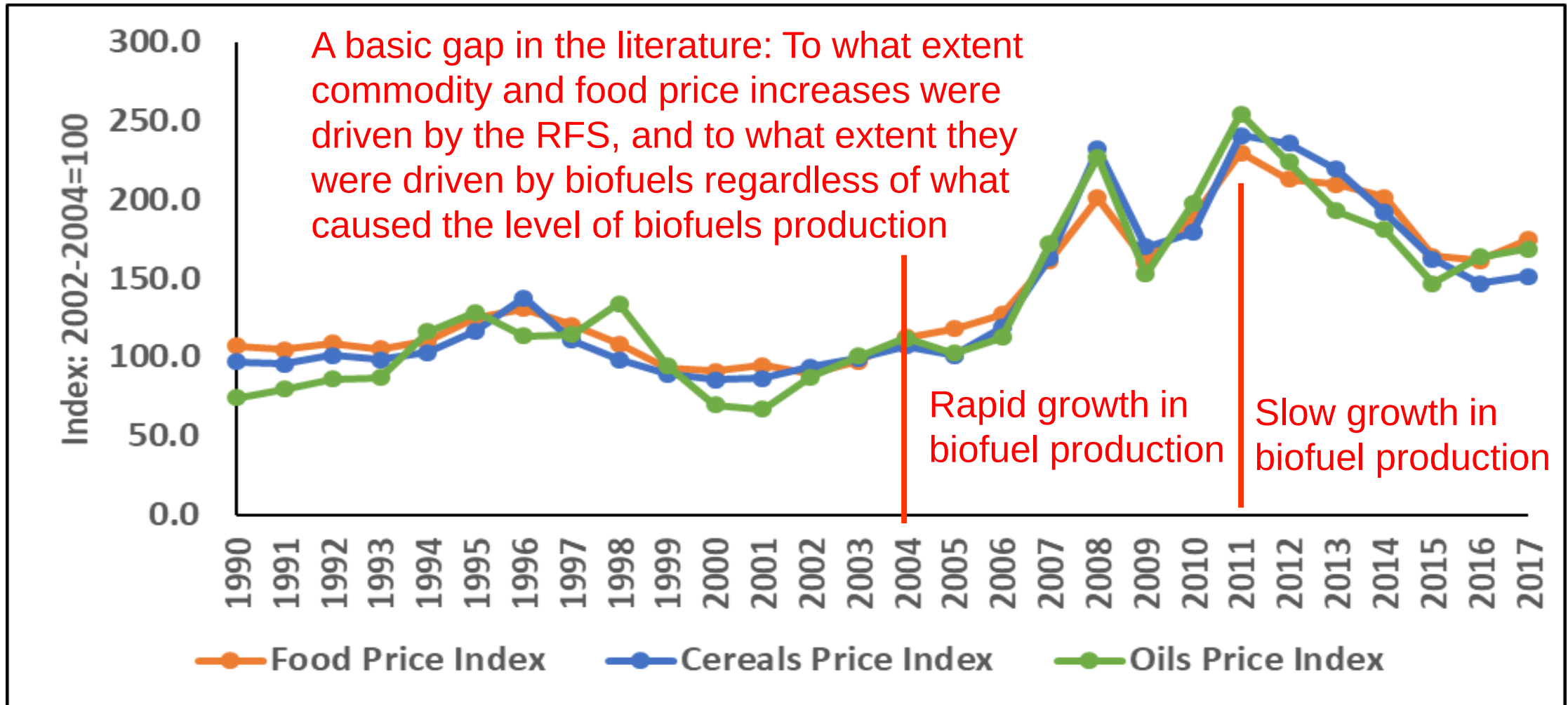
Introduction: Contributions of RFS to higher food prices



Major findings of the existing literature

- Over the past decade, many papers have studied the economic and environmental impacts of biofuel production and policy:
 - Welfare impact,
 - Impacts on commodity and food prices and also fuel prices,
 - Land use impacts and associated GHG emissions.
- In general, the existing literature has successfully identified the key drivers of the growth in biofuels,
- However, it basically has failed to properly quantify the impacts and contributions of RFS and Non-RFS drivers separately.

Trends on the global food prices: FAO data



Goals and contributions of this research

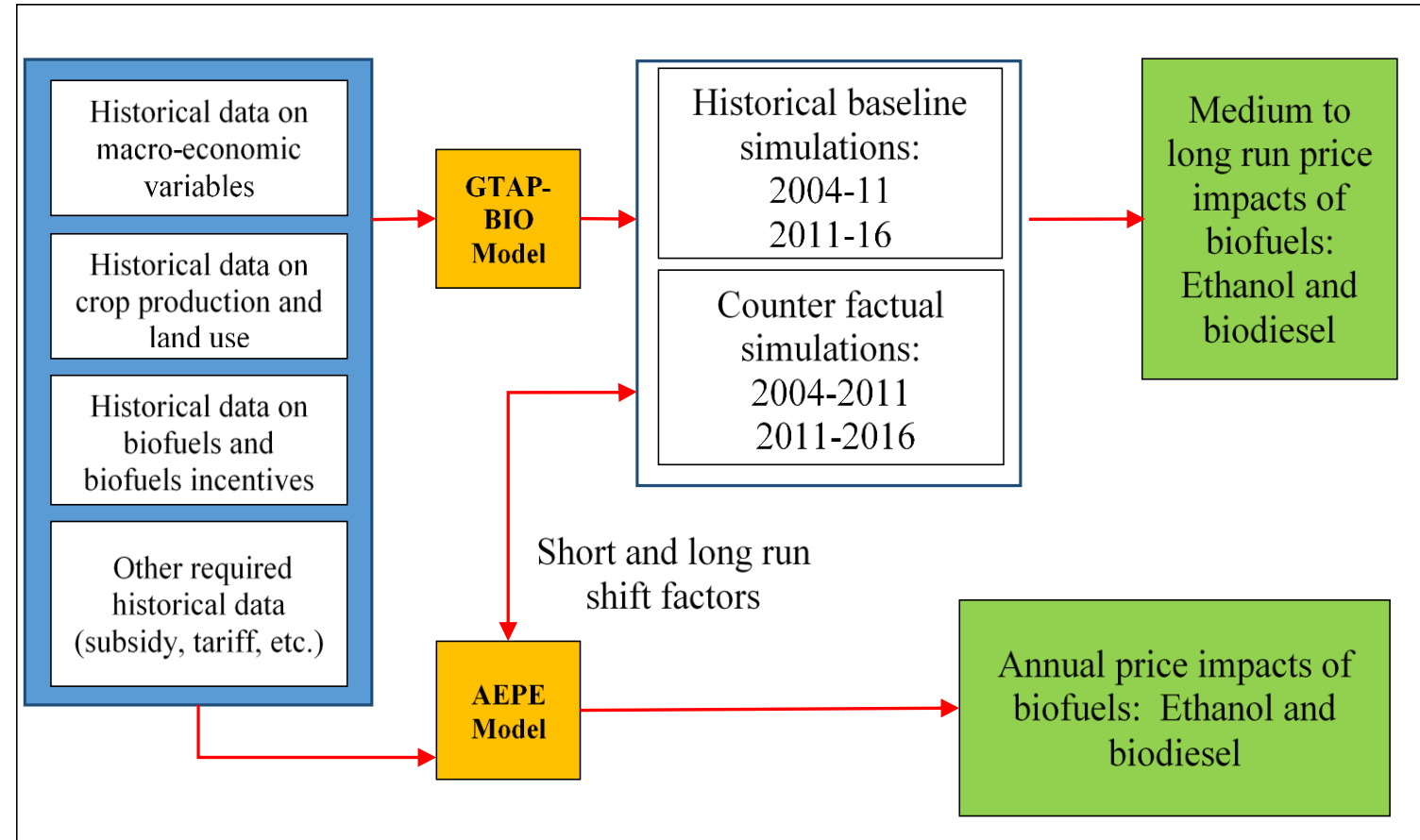
- This research provides a comprehensive review of the existing literature,
- It uses well-known Computable General Equilibrium (CGE) and Partial Economic (PE) models, to differentiate the economic impacts of the RFS from other drivers that have helped biofuels to grow,
- Among the economic impacts that biofuel production and policy could have, this paper concentrates on the two following items:
 - Food and commodity prices,
 - Contributions to agricultural resource utilization.

Summary of literature review

- The exiting literature and historical data confirm that prior to 2011 market forces were the main drivers of biofuel production:
 - Prior to 2000: Ethanol tax incentives and the Clean Air Acts Amendments of 1990 were the key policy drivers,
 - 2000 2011: Low crop prices until mid 2000s, high crude oil prices, the 2006 MTBE ban, and biofuels tax incentives,
 - Prior to 2011, the RFS was not binding and RINs prices were negligible,
- Since 2011 the US RFS and the 10% blend wall played more roles:
 - High RINs prices,
 - Fast growth in ethanol exports.

Research methodology and modeling approach

- To assess the short run, and long run price impacts of the US RFS, we make use of both a Computable General Equilibrium (CGE) model and a Partial Equilibrium (PE) models.
- The CGE model is used to assess the medium to long run price impacts of biofuels.
- The PE model assesses the annual and short term price impacts of biofuels

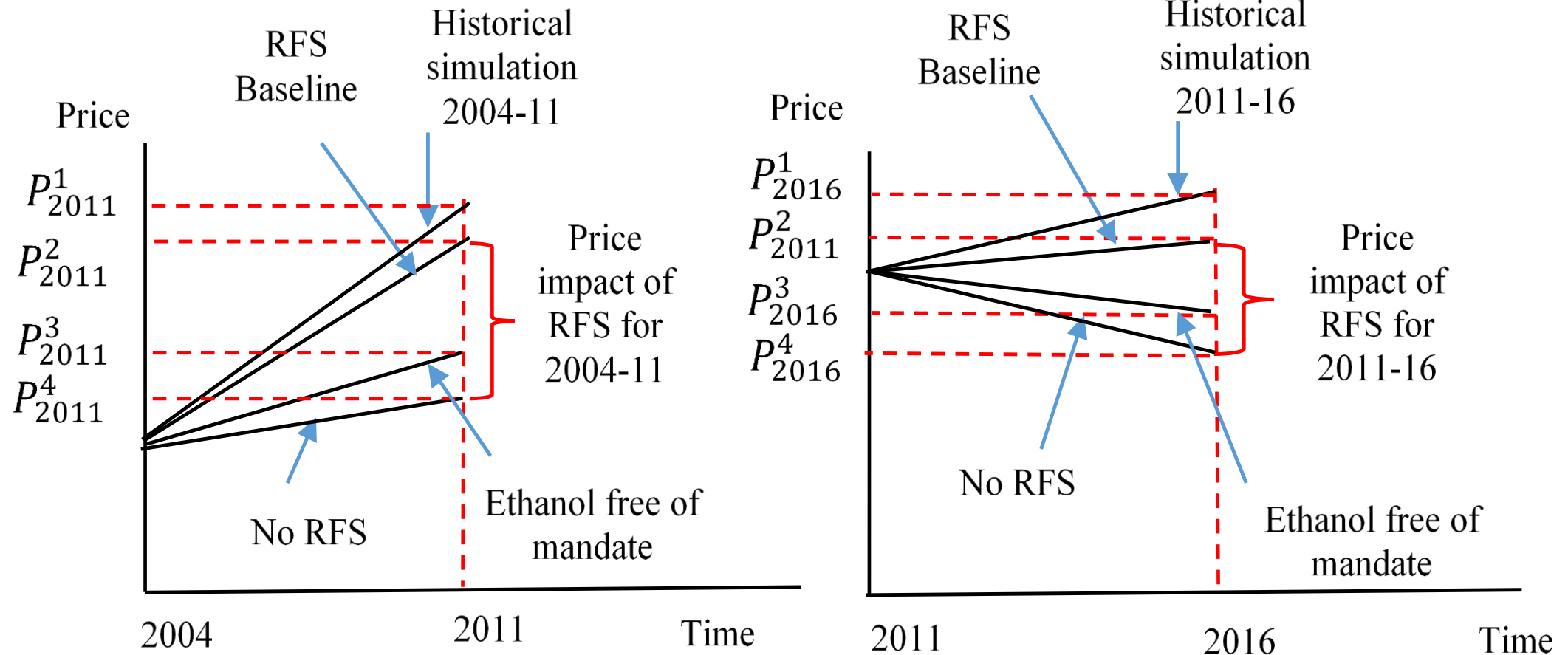


The overall modeling approach

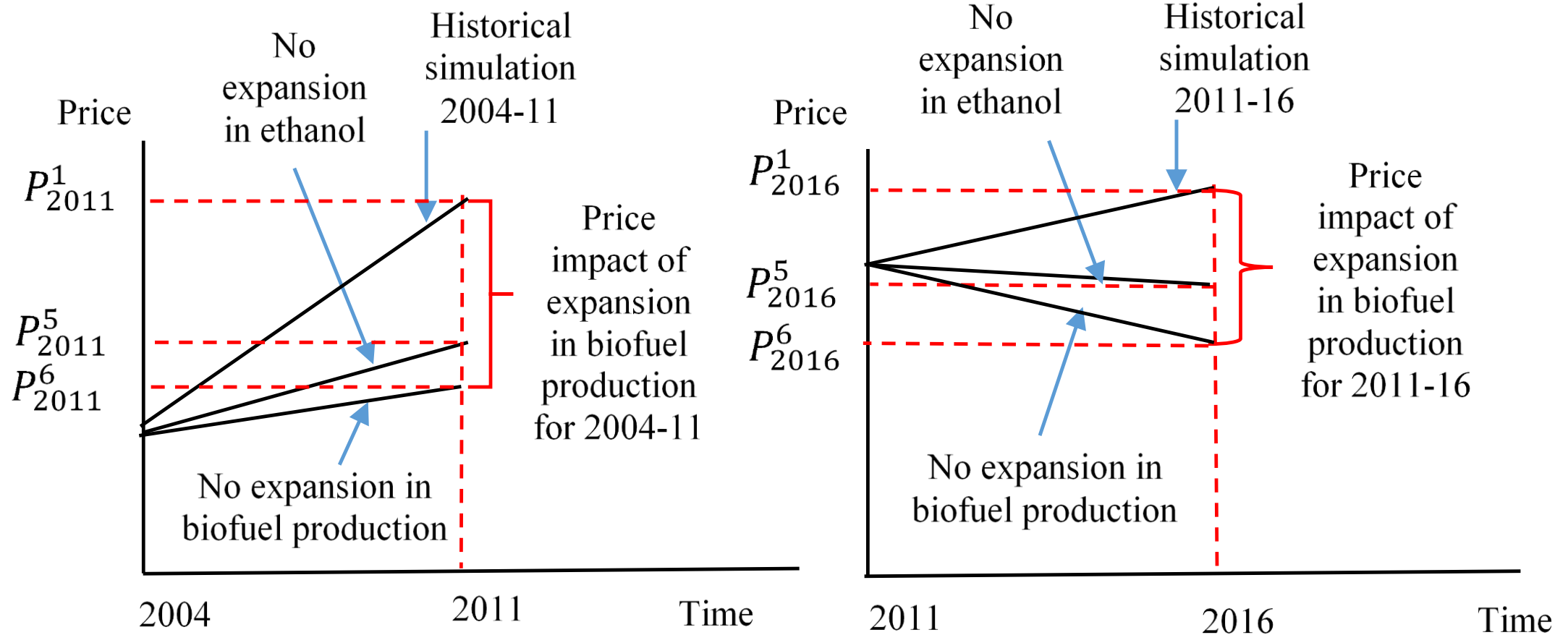
Examined experiments

- CGE baseline simulations:
 - **Historical baselines:** Simulations to replicate historical observations for 2004-11 and 2011-16. Macro variables, biofuels, and crop yields were targeted,
 - **RFS baseline:** RFS targets domestic consumption not production. Trade of biofuels were isolated,
- CGE counterfactual simulations:
 - **Ethanol free of mandate:** Remove RFS on ethanol, market determines its production and consumption,
 - **No RFS:** Remove mandates on ethanol and biodiesel both,
 - **No expansion in ethanol:** Repeat baseline for each time period, while freezing ethanol production,
 - **No expansion in biofuels:** Repeat baseline for each time period, while freezing ethanol production.
- AEPE: An annual historical baseline for the US main agriculture and energy markets: corn, soybeans, DDGS, livestock, ethanol, gasoline.
- AEPE counterfactual: Remove mandates and allow markets to operate, year by year.

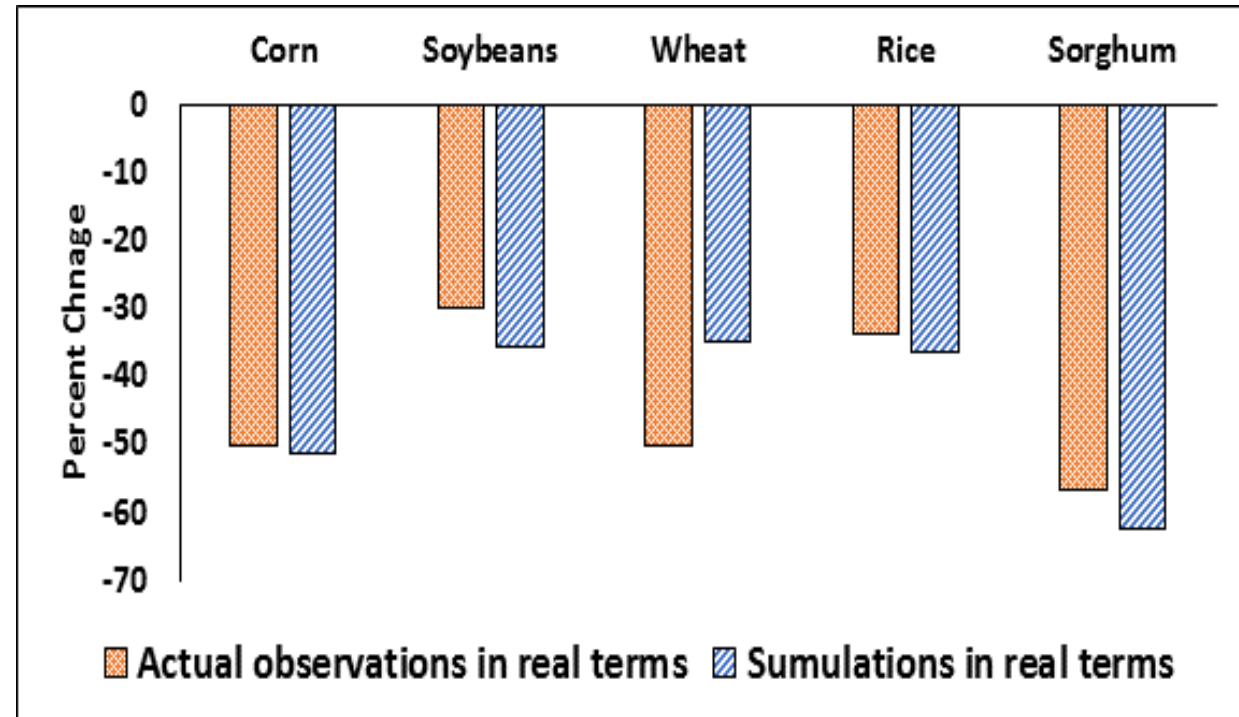
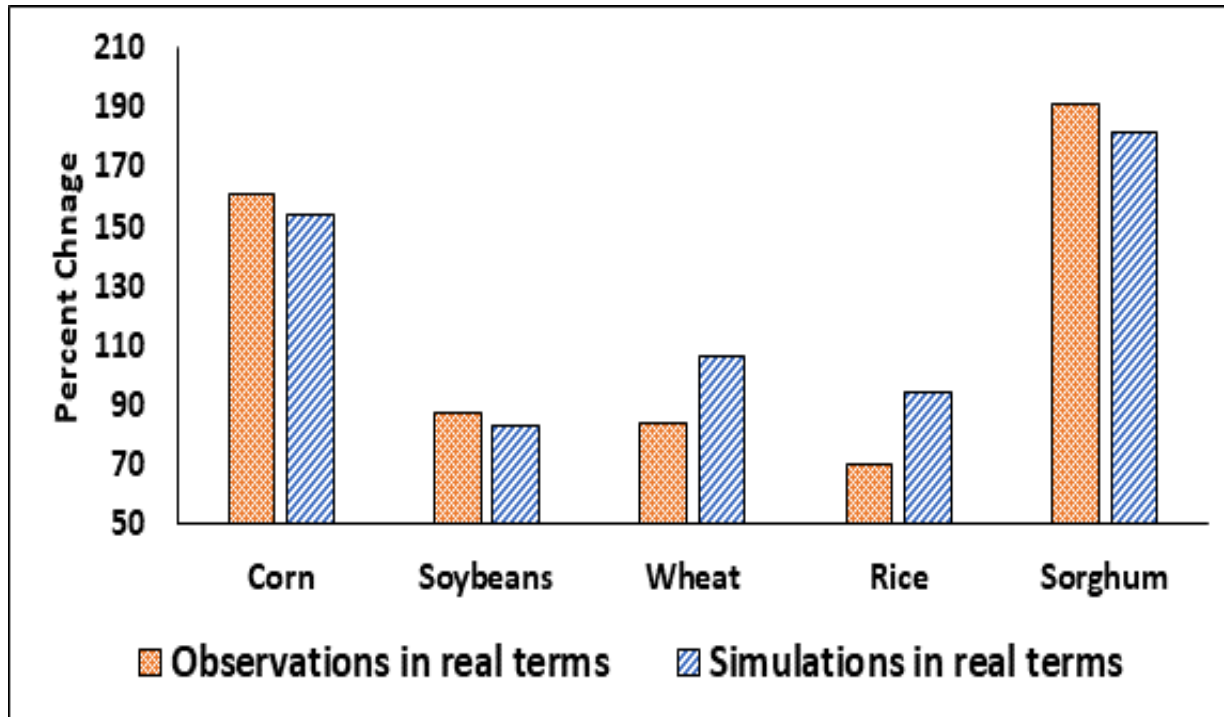
A schematic representation of the price impact of RFS



A schematic representation of the price impacts of biofuels



Model performance: Historical and simulated US crop prices



Observed and simulated percent change in real crop prices for time periods of 2004-11 (left panel) and 2011-16 (right panel).

Price and quantity impacts of RFS and biofuel production

Percent changes in crop outputs 2004-11 Percent changes in crop prices

Description	Removing mandate of corn ethanol	Removing mandates of corn ethanol & biodiesel	No expansion in corn ethanol	No expansion in biofuels
Coarse grains	-1.2	-1.4	-20.8	-20.8
Soybeans	0.2	-1.6	3.2	0.1
Wheat	0.1	0.6	2.4	3.0
Rice	0.0	0.2	0.7	1.0
Sorghum	0.0	0.0	0.6	0.6
Rapeseed	0.2	-12.4*	5.6	-11.0*
Other oilseeds	0.1	-4.3	1.8	-3.6
Sugar crops	0.0	0.1	0.4	0.4
Other crops	0.1	0.0	1.0	0.8

Description	Removing mandate of corn ethanol	Removing mandates of corn ethanol & biodiesel	No expansion in corn ethanol	No expansion in biofuels
Coarse grains	-0.3	-0.6	-5.3	-5.5
Soybeans	-0.1	-0.7	-1.6	-2.5
Wheat	-0.1	-0.2	-0.9	-1.1
Rice	-0.1	-0.2	-1.0	-1.2
Sorghum	-0.1	-0.2	-0.9	-1.1
Rapeseed	-0.1	-3.2	-1.3	-5.0
Other oilseeds	-0.1	-0.8	-0.9	-1.8
Sugar crops	-0.2	-0.5	-3.6	-4.0
Other crops	-0.1	-0.4	-1.7	-2.0

Price and quantity impacts of RFS and biofuel production

Percent changes in crop outputs 2011-16 Percent changes in crop prices

Description	Removing mandate of corn ethanol	Removing mandates of corn ethanol & biodiesel	No expansion in corn ethanol	No expansion in biofuels
Coarse grains	-2.0	-1.6	-1.6	-1.6
Soybeans	1.1	0.3	0.9	0.5
Wheat	0.8	0.4	0.6	0.3
Rice	1.1	1.2	0.9	1.1
Sorghum	0.0	0.5	0.0	0.4
Rapeseed	1.9	1.5	1.5	1.6
Other oilseeds	1.0	0.5	0.8	0.7
Sugar crops	0.6	0.5	0.6	0.6
Other crops	0.4	0.3	0.3	0.3

Description	Removing mandate of corn ethanol	Removing mandates of corn ethanol & biodiesel	No expansion in corn ethanol	No expansion in biofuels
Coarse grains	-0.9	-0.9	-0.7	-0.8
Soybeans	-0.3	-0.5	-0.2	-0.4
Wheat	-0.1	-0.1	-0.1	-0.1
Rice	-0.2	-0.3	-0.2	-0.3
Sorghum	-0.6	-0.6	-0.4	-0.5
Rapeseed	-0.2	-0.5	-0.2	-0.4
Other oilseeds	-0.2	-0.5	-0.2	-0.3
Sugar crops	-0.7	-0.8	-0.5	-0.7
Other crops	-0.3	-0.4	-0.3	-0.3

Changes in farm income due to RFS and biofuel changes

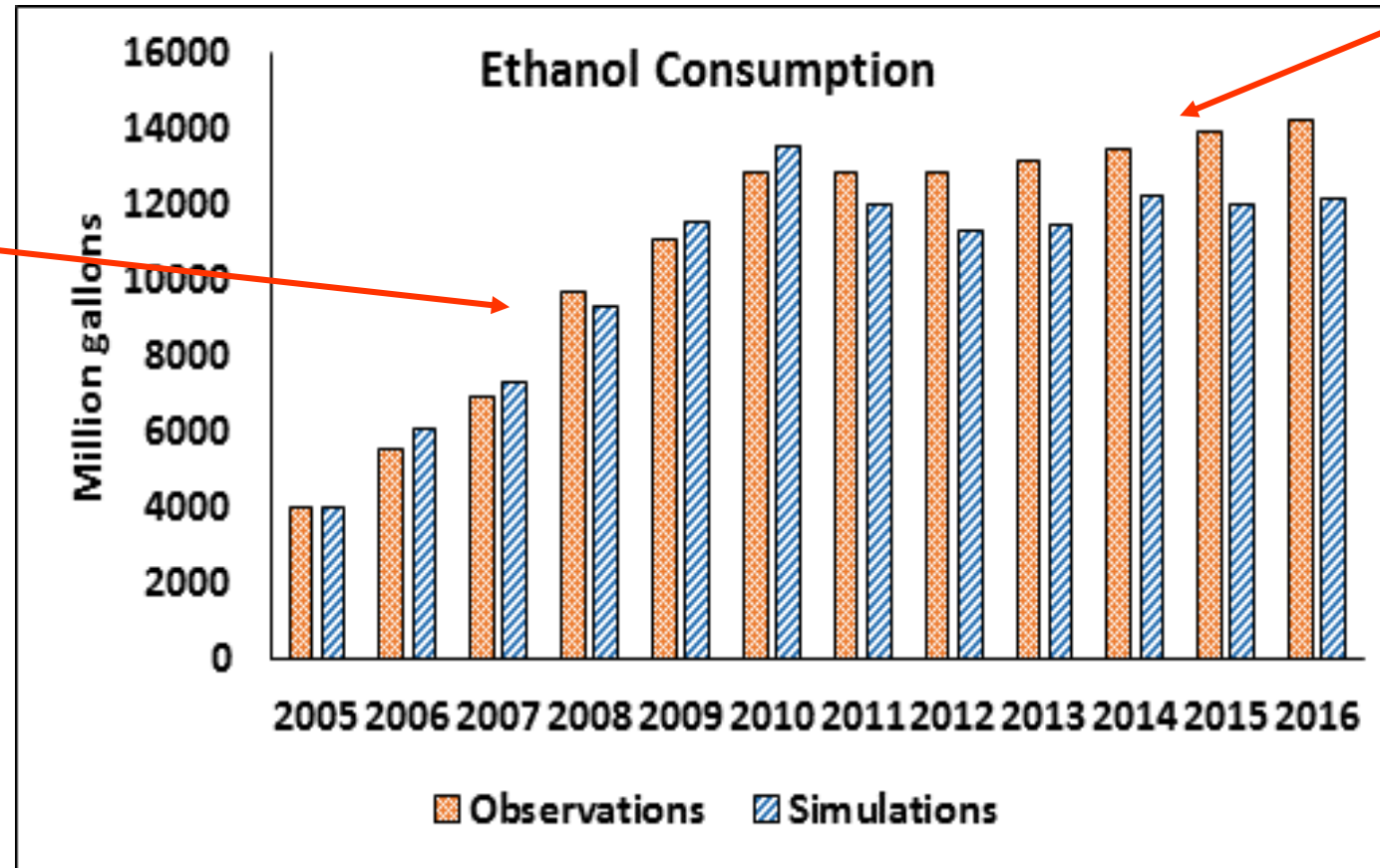
Description	Removing mandate of corn ethanol	Removing mandates of corn ethanol & biodiesel	No expansion in corn ethanol	No expansion in biofuels
Crop sectors	-461.6	-1,299.6	-6,923.8	-8,010.6
Overall agriculture	-478.9	-1,371.0	-7,143.3	-8,313.1

2004-11

Description	Removing mandate of corn ethanol	Removing mandates of corn ethanol & biodiesel	No expansion in corn ethanol	No expansion in biofuels
Crop sectors	-2,062.2	-2,454.8	-1,652.2	-2,281.2
Overall agriculture	-2,040.6	-2,414.2	-1,635.9	-2,222.6

2011-16

PE model annual short run analysis



Actual observations are larger than market simulation after 2011.

Actual observations and market simulations are not very different prior to 2011.

Actual and simulated market results: RFS is more effective after 2011

Key conclusions

- Our results confirm that, in general, the long run price impacts of biofuel production, regardless of the drivers, were not large.
- The long run impacts of RFS on crop and food prices were negligible. For example, only one-tenth of the 5.5% increase in the price of coarse grains was assigned to the RFS for the period of 2004-11.
- The long run CGE results indicate that biofuel production and policy made major contributions to the agricultural sector in both time periods.
- While biofuel production in general, and the RFS in particular, have had some positive impacts on crop prices and farm incomes, they basically help retain and keep agricultural resources in the sector.

Thanks
Questions and Comments