Doomed by Design: Structural Implications of the Renewable Fuel Standard for E85 Demand

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Renewable Fuel Standard

- Renewable Fuel Standard (RFS) sought to induce the consumption of high blend rates of ethanol from not only corn but also cellulosic feedstocks.
- Instead, a "blend wall" has emerged and limited the demand for ethanol to 10% of motor gasoline (E10) consumed while higher ethanol blend fuel (E85) is more costly at the energy equivalent basis.
- The current consumption of biofuels in the US has fallen short of the originally proposed RFS mandated volumes. (Fig. 1)
- Two design features of the RFS, specifically, nested structure and cellulosic waiver credit create the pathways of biodiesel overage.
- Compliance with the mandate requires the obligated parties to acquire tradable permits "Renewable Identification Number (RIN)"

Fig. 1 Unintended divergence in RFS compliance (Billion gallon 2017)

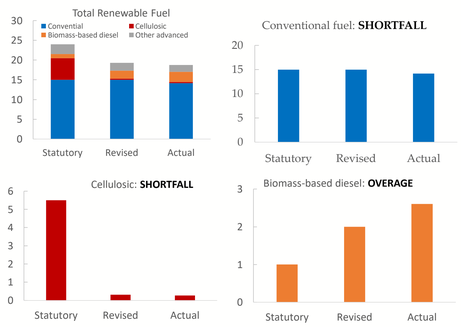
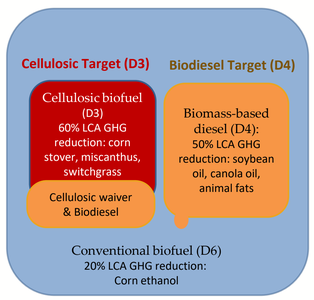


Fig. 2 RFS policy structure and different types of RINs



Research Question:
What are the factors behind the divergence of the RFS compliance?
What are the implications of design feature of the RFS on the fuel market?
What are the unintended consequences of the diversion in mandate compliance?

Literature

Mechanism of RFS does not consider blend wall
- Fuel tax and ethanol subsidy (de Gorter and Just, 2010; Lapan and Moschini, 2012; Cui et al., 2011)

Blend wall studies assume complete RIN pass-through
- Price E85 at least parity or lower (Du & Li, 2015; Pouliot and Babcock,2015)

Empirical evidence about incomplete RIN pass-through
- 0 to 30% RIN passed through to retail E85 price (Knittel and Meiselman, 2016). 50% to 75% of RIN passed through to E85 (Lade and Bushnell, 2018)

Biodiesel overage
- Biodiesel overage in the presence of a binding blend wall with nested structure as marginal compliance fuel (Korting, 2017; Irwin, 2013; Lade, 2016)

Research gap
- Not discussed are the consequences of the divergence in compliance on retail fuel prices of E10 and E85
- Or the rationale behind incomplete RIN pass-through

Partial Equilibrium Conceptual Framework

$$max \quad \text{Social Welfare} =$$

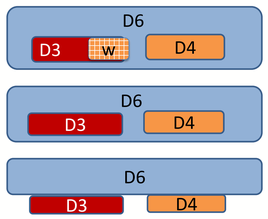
$$\int_0^{q_{gf}} D_{gf}(\cdot)dq_{gf} + \int_0^{q_{df}} D_{df}(\cdot)dq_{df} \quad \text{Consumer surplus}$$

$$-\int_0^{q_e} S_e(\cdot)dq_e - \int_0^{q_c} S_c(\cdot)dq_c - \int_0^{q_b} S_b(\cdot)dq_b - \int_0^{q_g} S_g(\cdot)dq_g - \int_0^{q_d} S_d(\cdot)dq_d \quad \text{Producer surplus}$$

$$-C(q_{gf}, q_{df}) - P_{cw}q_{cw} + t_B q_b \quad \text{Blending cost, waiver cost, tax credit}$$

Three Policy scenarios:

1. Nested with the waiver
2. Nested without the waiver:
3. Non-nested



D6: Conventional biofuel
D4: Biomass-based diesel
D3: Cellulosic biofuel
W: Cellulosic waiver

Analytical Result

Structural difference in RIN pass-through at blend wall

PROPOSITION 1: Non-nested RFS mandate secures the complete RIN pass-through and prices of E10 and E85 at the energy parity, regardless of biodiesel production.

$$P_{gf}^{E85} - P_{gf}^{E10} = \left(\mu\frac{S_e(\cdot)q_e + S_c(\cdot)q_c}{q_e+q_c} + \nu S_g(\cdot)\right) - \mu\frac{P_{D6}\times q_e + P_{D3}\times q_c}{q_e+q_c} + \nu(\lambda_c\theta_c + \lambda_b\theta_b + \lambda_r\theta_r)$$

Production cost gap — Net RINs incentive

$$q_{E85} \geq 0 \quad P_{gf}^{E85} = P_{gf}^{E10} \quad \text{Pass-through} = \frac{\text{Net RINs incentive}}{\text{Production cost gap}} = 100\%$$

PROPOSITION 2: Existing biodiesel overage under nested RFS mandate prevents full RIN pass-through from wholesale ethanol to retail E85 resulting in higher E85 price compared to E10.

$$q_{E85} = \frac{-[q_{D4} - \theta_b(q_g + q_d)]}{0.74 - 0.26(\theta_r - \theta_b)} < 0 \quad P_{gf}^{E85} > P_{gf}^{E10} \quad \text{Pass-through} = \frac{\text{Net RINs incentive}}{\text{Production cost gap}} < 100\%$$

Strategic overage hinges on the supply elasticity

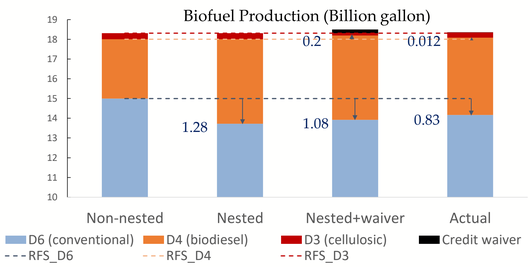
PROPOSITION 3: Nested structure stimulates blenders to choose the biodiesel pathway instead of the ethanol pathway to comply with the mandate when elasticity-weighted marginal cost of using biodiesel is lower than corn ethanol

$$\left(\frac{1}{\eta_b} + 1\right) S_b(q_b) < \left(\frac{1}{\eta_e} + 1\right) S_e(q_e)$$

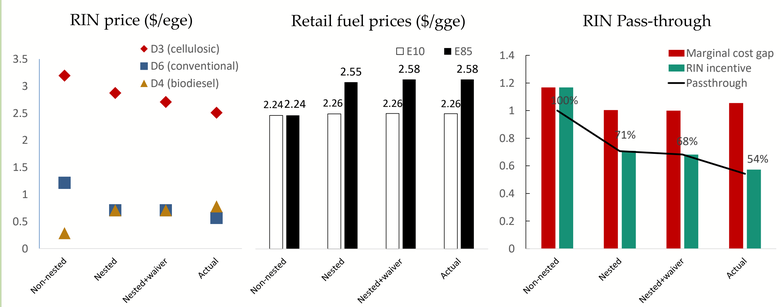
PROPOSITION 4: The provision of **a cellulosic waiver** will lead blenders to further substitute biodiesel for ethanol to meet the total renewable fuel mandate when elasticity-weighted marginal cost of using biodiesel is lowest

$$\left(\frac{1}{\eta_b} + 1\right) S_b(q_b) < \left(\frac{1}{\eta_e} + 1\right) S_e(q_e) < \left(\frac{1}{\eta_c} + 1\right) S_c(q_c).$$

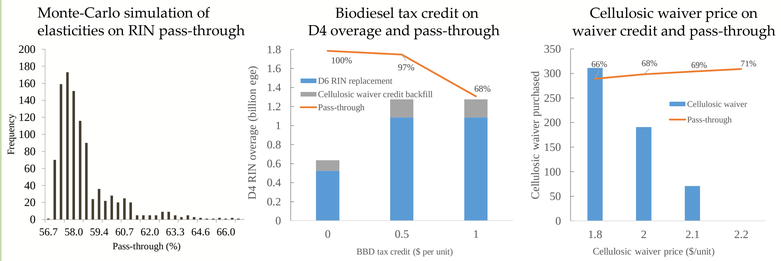
Simulation Results



Design features of the RFS create two pathways of biodiesel loopholes:
(1) Backfilling of the cellulosic waiver; (2) Replacing the conventional biofuel



Over-produced biodiesel reduces ethanol RINs values, widens the price spread between E10 and E85, and undermines the RIN pass-through.



The sensitivity analysis validates that the main driver of RIN pass-through is the lower elasticity-weighted marginal cost of biodiesel. The biodiesel tax credit contributes to the biodiesel overage and lower RIN pass-through. The role of cellulosic waiver in affecting the pass-through is limited.

Conclusion and Policy Implication

- The design features of RFS including nested structure and the cellulosic biofuel waiver credit induces biodiesel overage and disincentives to lower E85 price.
- Blending choice hinges on the relative elasticity-weighted marginal costs of corn ethanol, biomass-based diesel, and cellulosic biofuels.
- The unintended consequence of RFS shows that there is loophole within the RFS structural design allowing biomass-based diesel to be overaged.

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