Industry Compliance Costs Under the Renewable Fuel Standard: Evidence from Compliance Credits

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Introduction

What is the Renewable Fuel Standard (RFS)?

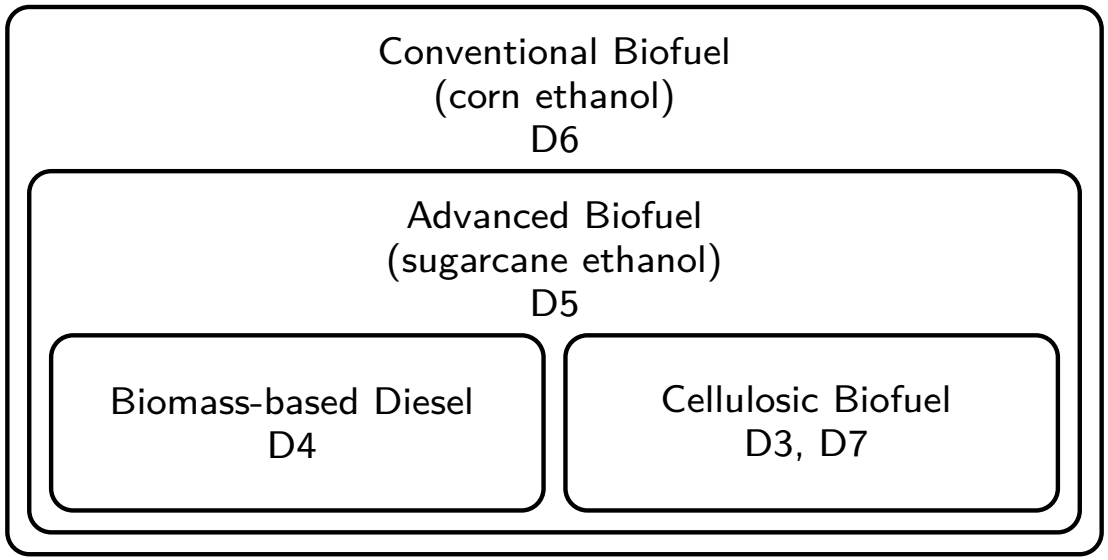
- It is the law in the United States that requires oil (fuel) refineries to blend a mandated volume of biofuels into transportation fuels
- Created by the *Energy Policy Act* of 2005 and expanded by the *Energy Independence and Security Act* of 2007
- A market-based policy similar to pollution permits

Important design elements of the RFS:

- Regulated firms can comply with the RFS by:
  - blending biofuel into transportation fuel, or
  - buying compliance credits known as “Renewable Identification Numbers" (RINs)
- RINs are created by biorefineries upon production of biofuel
- RINs are split from biofuel upon fuel blending
- RINs are tradeable compliance credits

Structure of the Nested RFS Mandate

RFS is a nested mandate, meaning blending higher-level biofuels also works to meet the mandate requirements



Price hierarchy (Whistance and Thompson, 2014 *AEPP*):

$$D6 \text{ RIN price} \leq D5 \text{ RIN price} \leq \min\{D4, D3, D7 \text{ RIN price}\}$$

What Do We Know About RFS Compliance Costs?

A rich literature documents that oil refiners are able to fully pass the cost of RINs onto consumers

- Burkhardt (2016, *WP*)
- Knittel, Meiselman, and Stock (2017, *JAERE*)
- Pouliot, Smith, and Stock (2017, *WP*)
- Li and Stock (2019, *JEEM*)
- Lade and Bushnell (2019, *JAERE*)

Does this mean compliance costs are near-zero (no RFS impact) on US oil refiners?

- Profit margins on gasoline sales lost to ethanol
- Costs associated with biofuel procurement

Objectives of the Present Study

This paper explores:

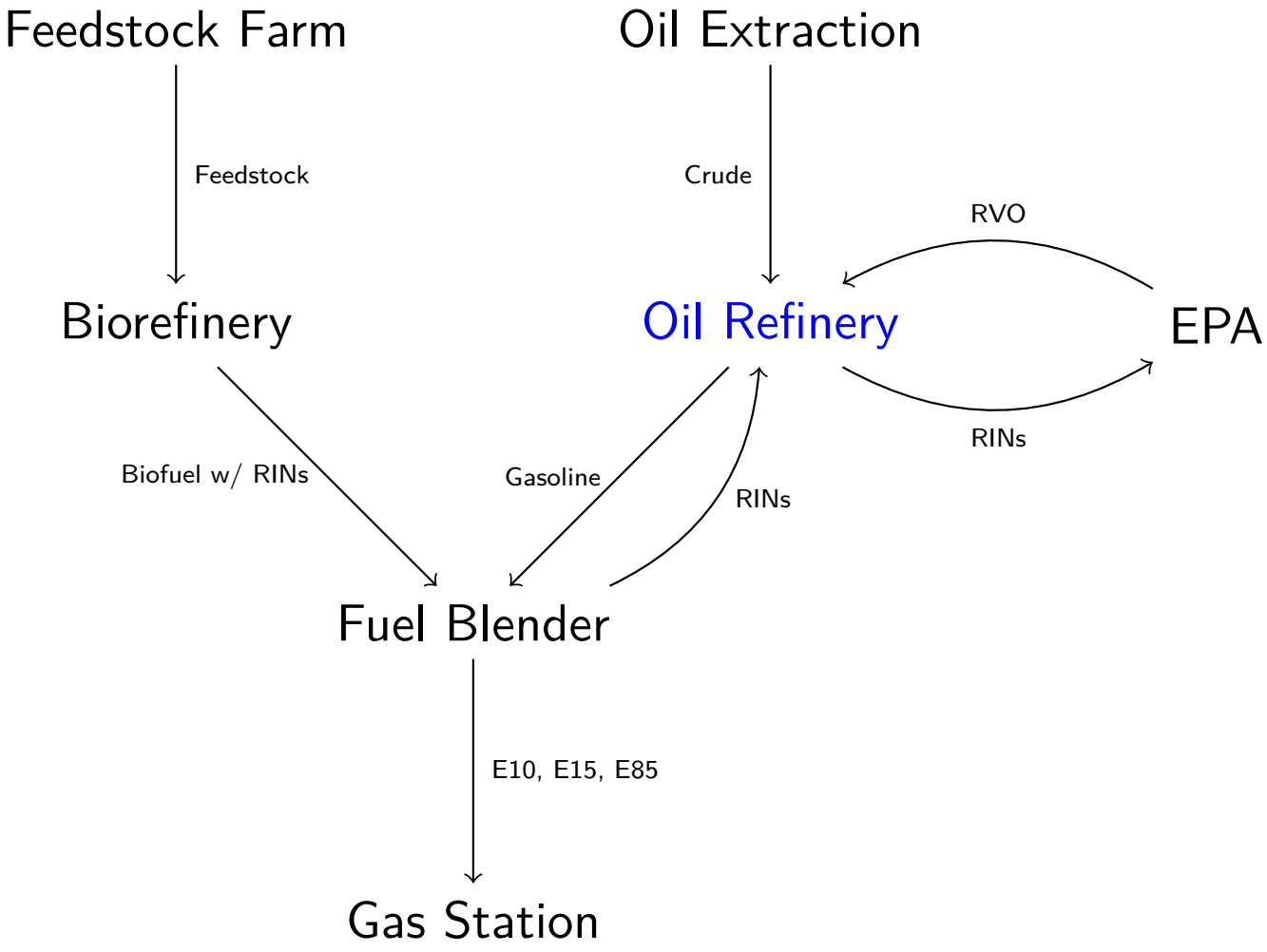
- How the RFS—changes in RIN prices—impacts the stock prices of oil refining firms
- Whether regulated firms are heterogeneous in those price responses
- What those heterogeneities mean for policy

Anecdotal Evidence

Outside academic work, refiners themselves make a number of claims about how the RFS impacts them

- Merchant refiners claim that integrated refiners use their ability to generate their own RINs to hoard them and generate windfall profits, thus disadvantaging smaller ones (EPA, 2017, pp. 21-31)
  - Merchant refiner = Oil refiner
  - Integrated refiner = Oil refiner + Fuel blender (+ Biorefinery, sometimes)
- Large refiners tend to represent RINs as a pure loss to the firm
  - The Small Refinery Exemption (SRE) system

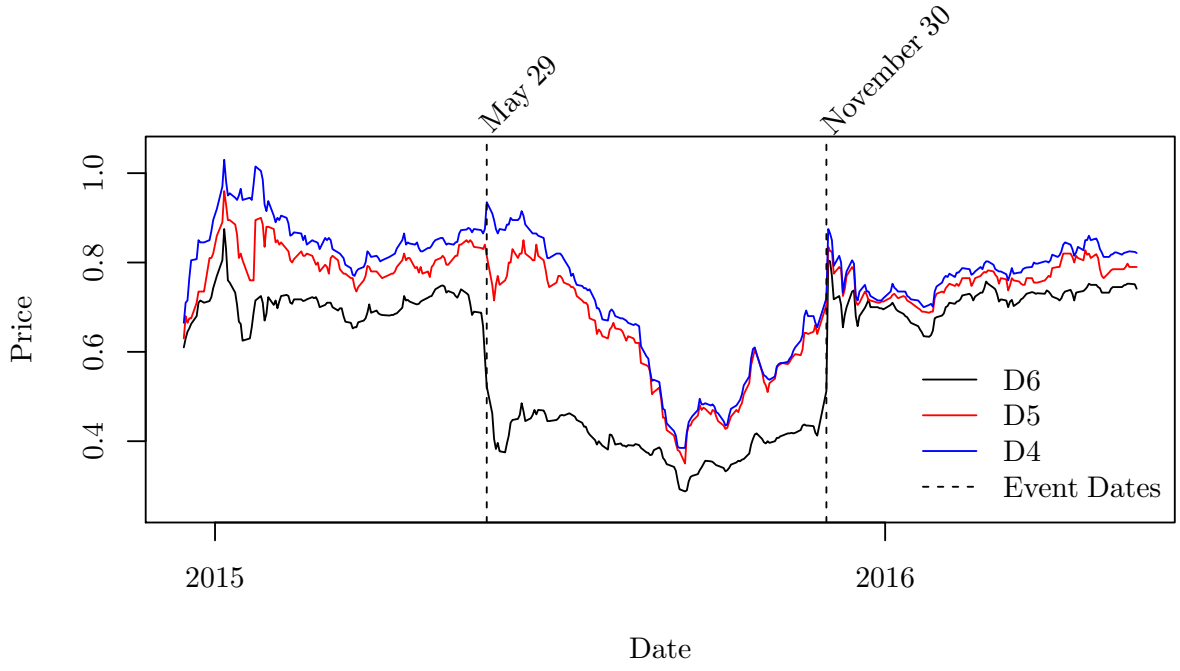
Fuel Refining and Ethanol Blending With the RFS



Data

Limit the analysis to a single year (2015) because RINs are tied to the compliance year they were generated in

- Congress set statutory RFS volume mandates optimistically high
- EPA reviews and adjusts them yearly to prevent undue financial pressure
- EPA makes two announcements each year:
  - Proposed rule (for public comments)
  - Final rule



Data

Daily price data for D6, D5, D4 RINs comes from the Oil Price Information Services

Daily stock price data for 12 publicly-traded refining firms comes from Finaeon Global Financial Data

Table 1: Firm Characteristics with Ticker Symbols

Large (>$100B)	Medium (< $100B, > $10B)	Small (<$10B)
British Petroleum (BP)	Marathon (MPC)	Andeavor (ANDV)
Chevron (CVX)	Phillips 66 (PSX)	Carlyle Group (CG)
Exxon Mobil (XOM)	Valero (VLO)	HollyFrontier (HFC)
Shell (RDS.A)		Western Refining (WNR)
Total (TOT)		

Firm size is measured based on market capitalization (Fama and French, 1992, *JF*).

Summary Statistics and Stationarity Tests

Table 2: Summary Statistics and Stationarity Tests

	Summary Statistics			Stationarity Tests		
	Mean	St. Dev	N	ADF	KPSS	LS
Null:				Non-stationary	Stationary	Non-stationary
D6	0.599	0.155	357	-1.557	1.195***	-1.931
D5	0.721	0.119	357	-1.63	1.191***	-1.019
D4	0.759	0.134	357	-1.491	1.488***	-0.255
VLO	61.348	6.084	357	-2.418	2.193***	-1.289
MPC	47.095	6.803	357	-2.401	2.148***	-1.188
XOM	83.017	5.428	357	-1.074	2.219***	-3.209
PSX	80.016	5.891	357	-2.931	2.521***	-1.235
CVX	95.619	10.382	357	-1.128	2.884***	-2.287
BP	35.646	4.618	357	-2.283	4.59***	-1.228
HFC	40.786	6.097	357	-1.462	1.291***	-2.297
RDS.A	54.629	7.506	357	-2.278	4.985***	-2.911
CG	22.013	5.712	357	-1.587	5.098***	-1.241
TOT	48.612	3.386	357	-2.972	3.115***	-2.857
ANDV	90.752	11.307	357	-2.067	1.146***	-2.147
WNR	39.37	7.515	357	-1.793	3.153***	-1.784

LS is Lee and Strazicich (2003, *RESTAT*) stationarity test that is robust to the presence of structural breaks. Significance at 1%, 5%, and 10% levels are reported with *, **, and ***, respectively.

Methods

We employ two reduced-form methods to identify how varying RIN costs impact regulated refiners:

1. Bivariate time series analysis
   - To show how RIN prices and stock prices associate with one another day-to-day
   - No causal interpretation because there is underlying endogeneity unaccounted for in the model (both series are simultaneously determined by crude oil prices, commodity prices, consumer fuel demand, etc.)
2. Event study analysis

Table 3: Johansen's Cointegration Tests

	Maximal Eigenvalue			Trace		
Firm	D6	D5	D4	D6	D5	D4
VLO	9.149	8.989	9.545	12.715	11.815	12.01
MPC	7.03	4.163	3.592	8.411	5.76	5.262
XOM	6.274	13.445	14.511*	8.205	15.241	16.873
PSX	11.09	11.629	11.611	15.435	16.191	14.973
CVX	5.398	12.12	15.281*	7.26	14.465	18*
BP	3.101	3.23	3.991	5.124	4.806	5.679
HFC	14.452*	7.104	5.756	15.397	7.869	6.54
RDS.A	3.982	4.823	5.185	6.318	7.089	7.526
CG	8.224	5.167	5.019	9.992	6.558	6.069
TOT	6.366	9.4	10.126	9.947	11.882	12.734
ANDV	10.42	8.689	8.086	13.325	10.747	9.988
WNR	6.037	3.999	3.261	6.677	4.685	3.916

Significance at 1%, 5%, and 10% levels are reported with *, **, and ***, respectively.

Bivariate Time Series

Based on cointegration test, we model every RIN $\times$ firm pair using a bivariate VAR

$$\begin{aligned} \Delta FIRM_t &= c_1 + \sum_{l=1}^{m} (\phi_{1,1}^{l} \Delta FIRM_{t-l} + \phi_{1,2}^{l} \Delta RIN_{t-l}) + e_{1,t} \\ \Delta RIN_t &= c_2 + \sum_{l=1}^{m} (\phi_{2,1}^{l} \Delta FIRM_{t-l} + \phi_{2,2}^{l} \Delta RIN_{t-l}) + e_{2,t} \end{aligned} \tag{1}$$

Bivariate Time Series Results: D6

D6	VLO	MPC	XOM	PSX	CVX	BP	HFC	RDS.A	CG	TOT	ANDV	WNR
Constant	0.022	-0.014	-0.008	0.024	-0.022	-0.016	-0.027	-0.039	-0.022	-0.008	0.008	-0.039
Lag 1	-2.661	-0.781	-1.852	-2.019	-1.395	-1.398	-0.143	-0.806	-0.323	-1.106	-4.946	-2.566
Lag 2	2.652	-1.963	0.671	1.61	1.45	1.425	0.915	5.309*	1.584	0.847	3.239	1.529
Lag 3			0.958		-2.598	-3.274*		-6.347**				
Lag 4			-5.482*									
Obs.	354	354	352	354	353	353	354	353	354	354	354	354

Significance at 1%, 5%, and 10% levels are reported with *, **, and ***, respectively.

Bivariate Time Series Results: D5

D5	VLO	MPC	XOM	PSX	CVX	BP	HFC	RDS.A	CG	TOT	ANDV	WNR
Constant	0.026	-0.013	-0.014	0.024	-0.028	-0.018	-0.026	-0.044	-0.026	-0.008	0.009	-0.041
Lag 1	-1.411	-1.293	1.944	-2.969	1.138	0.053	-0.335	1.844	1.373	-0.982	-2.049	-1.806
Lag 2			-3.024	1.476	-2.446	-2.541		-1.647	0.825	-0.301		
Lag 3			-0.493		-3.867	-0.914		-2.44	-0.989	-3.589		
Lag 4			-5.137*		-10.814**	-5.167***		-9.733***		-6.292***		
Lag 5			-5.524*									
Lag 6			3.759									
Obs.	355	355	350	354	352	352	355	352	353	352	355	355

Significance at 1%, 5%, and 10% levels are reported with *, **, and ***, respectively.

Bivariate Time Series Results: D4 RINs

D4	VLO	MPC	XOM	PSX	CVX	BP	HFC	RDS.A	CG	TOT	ANDV	WNR
Constant	0.027	-0.014	-0.009	0.024	-0.021	-0.015	-0.025	-0.039	-0.022	-0.009	0.009	-0.038
Lag 1	-4.379	-3.097	-1.36	-6.469	-1.377	-0.703	-3.303	0.229	-1.299	-2.233	-5.322	-3.943
Lag 2		-1.136	3.251	3.988	3.5	0.291		4.519	0.946	4.519	1.417	-0.298
Lag 3			-1.405		-5.277			-6.442**		-6.906***		
Lag 4			-4.864									
Obs.	355	354	352	354	353	354	355	353	354	353	354	354

Significance at 1%, 5%, and 10% levels are reported with *, **, and ***, respectively.

Impulse Response Functions

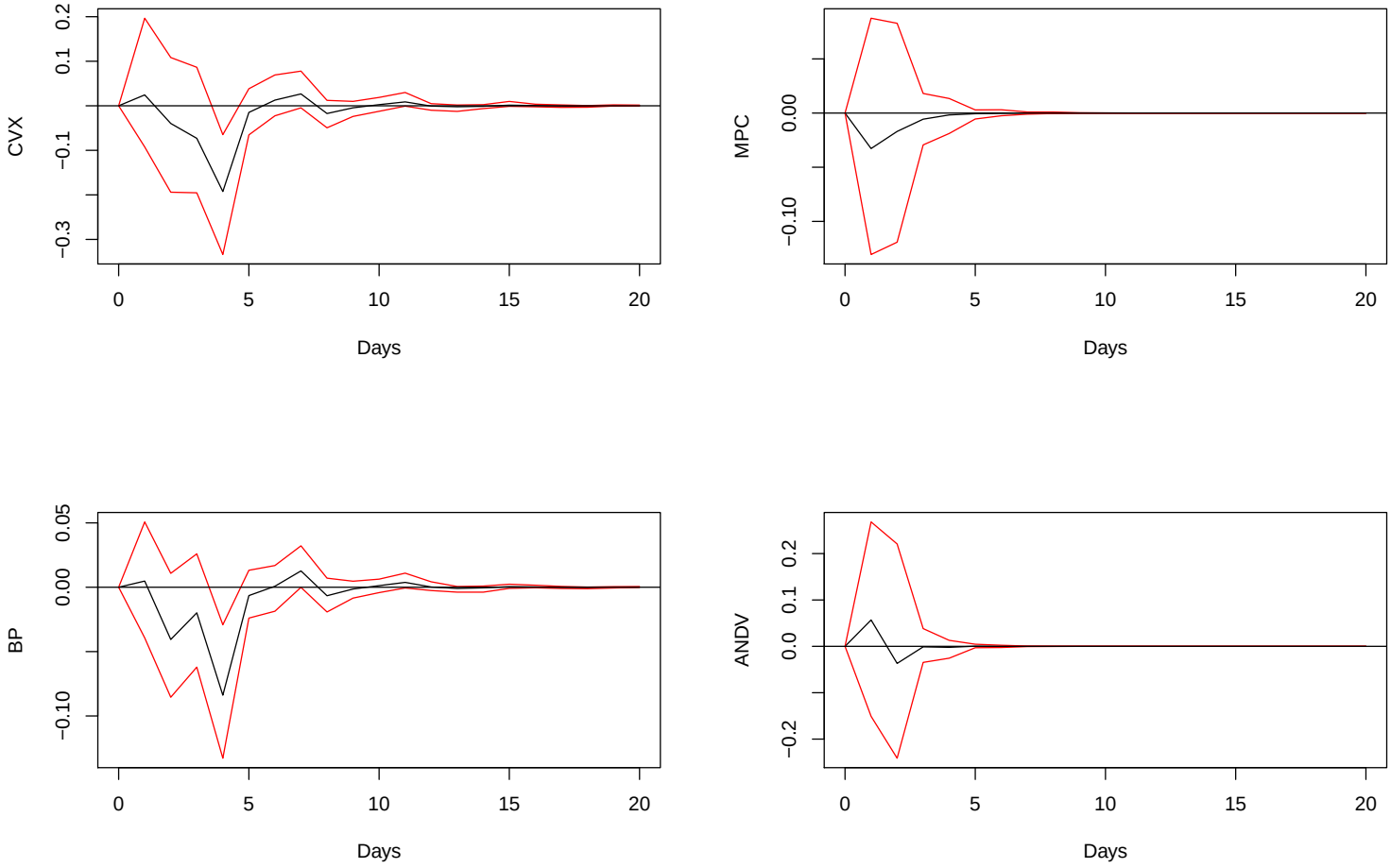
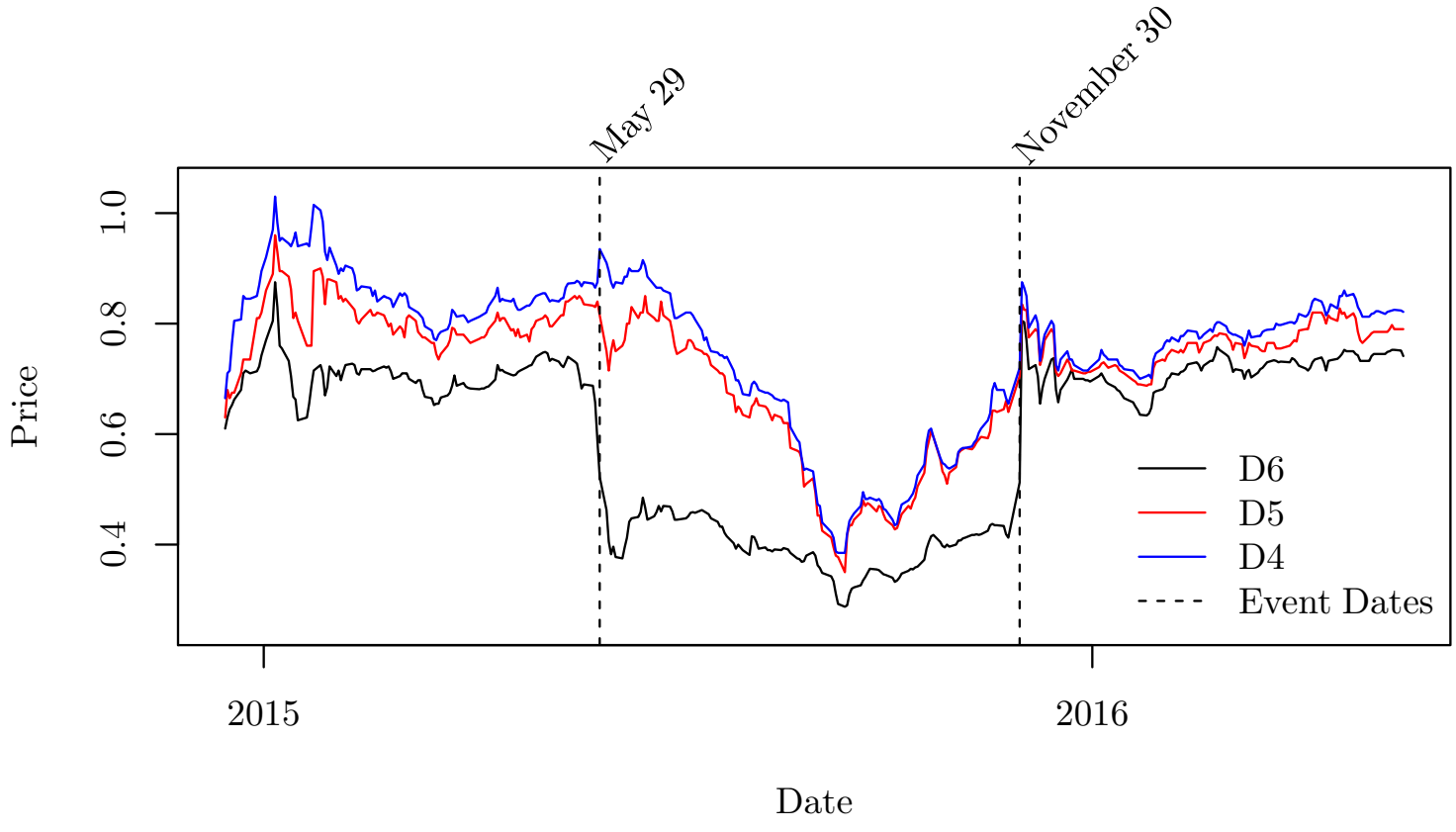


Figure 1: Orthogonal Impulse Responses from a Shock to D5 RINs, Selected Large Firms (Left) and Small/Medium Firms (Right)

Toward a Causal Interpretation: 2015 Shocks

- Take advantage of unanticipated regulatory announcements that caused major swings in RIN prices around announcement dates to identify RFS impact on every firm
- The two shocks are plausibly exogenous and large in magnitude



Event Study

Similar to Lade, Lin Lawell, and Smith (2018, *AJAE*), we estimate

$$\Delta \ln(Y_{i,t}) = \beta_0 + \sum_{i=1}^{p} \beta_i t^i + \sum_{i=1}^{s} \sum_{i=0}^{m} \gamma_{s,m} 1(t \in \{\mathbb{T} + m\}) + \mathbf{\Theta}' \Delta \ln(\mathbf{X_t}) + \lambda_{\text{MoY}} + \lambda_{\text{DoW}} + e_{i,t} \quad (2)$$

- $Y_{i,t}$ is stock price for refiner i on day t
- $1(t \in \{\mathbb{T} + m\})$ is indicator for events and their lags
- $\mathbf{X_t}$ is normal returns for day t (RUS3000 index)
- λ is month of year (MoY) and day of week (DoW) fixed effects
- p=4 and m=6

Event Study Results

	Large Firms	Medium Firms	Small Firms	All Firms
Event 1 (Proposed Rule)				
Lag 0	0.007	0.011	0.005	0.007
Lag 1	-0.005	-0.005	-0.008	-0.006
Lag 2	0.01	-0.009	-0.022	-0.006
Lag 3	-0.008	-0.018	-0.015	-0.013
Lag 4	-0.002	-0.008	0.001	-0.003
Lag 5	0.001	0.005	0.014	0.006
Lag 6	0.009	0.002	0.006	0.006
Event 2 (Final Rule)				
Lag 0	0.01	-0.003	-0.005	0.001
Lag 1	-0.01	-0.002	0.011	-0.001
Lag 2	-0.014	-0.005	-0.016	-0.012
Lag 3	0.001	-0.017	0.004	-0.002
Lag 4	-0.03**	-0.005	-0.013	-0.018
Lag 5	-0.024*	-0.013	-0.003	-0.014
Lag 6	-0.009	-0.001	0.002	-0.003
Number of Firms	5	3	4	12
Obs.	1780	1068	1424	4272

Significance at 1%, 5%, and 10% levels are reported with *, **, and ***, respectively.

Conclusion

Main findings:

- Large refineries lose value 3-5 days after a D5/D4 RIN price increase
- Small and medium firms do not significantly respond

Policy implications:

- Findings cast doubt on concerns that the RFS allows integrated refiners to abuse merchant refiners
- Findings question the necessity of Small Refinery Exemptions, which are intended to shield small, financially vulnerable refiners from RFS compliance costs