Online Appendix for

Fuel Subsidy Pass-Through and Market Structure: Evidence from the Renewable Fuel Standard

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A Unit Root and Cointegration Tests

Testing whether retail E85 prices are stationary requires selecting a panel unit root test. Several tests are available. Many use variations of an augmented Dickey-Fuller (ADF) test (Levin et al., 2002; Im et al., 2003), while others use residual-based Lagrange multiplier tests (Hadri, 2000). The appropriateness of each depends on the relative speed of asymptotic convergence between the cross-sectional and time series observations, whether one assumes common or heterogeneous coefficients on the lagged independent variable, and whether the panel is balanced. Similar issues arise with panel cointegration tests. A more practical matter guides our choice – our panel has gaps and is unbalanced. The most practical unit root test is, therefore, the Fisher-type test proposed by Choi (2001) that combines p-values from individual ADF tests for each station in our sample.

Table A.1 reports unit root and cointegration test results for all price series used in our analysis. We report three test statistics for E85 station prices: (i) a Fisher inverse chi-squared test that combines the p-values from station unit root tests; (ii) a Fisher test that subtracts the cross-sectional means from all E85 price series; and (iii) a summary of the percent of station-level ADF tests that are rejected at the 5% level. We also present approximate p-values for ADF tests of the E85 subsidy and the average wholesale E85 prices. For every test, we include two, four, and six weekly lags.

Results from the E85 price stationarity tests yield mixed conclusions. We cannot reject the null hypothesis that every E85 price panel contains a unit root when we include a trend in the Fisher test but can reject the null hypothesis with two and four lags when we control for cross-sectional correlation between E85 prices and demean the series. The null hypothesis of a unit root in each station's E85 prices is only rejected for around 5% of stations, suggesting that a few outlier stations may drive the sensitivity of the tests. We cannot reject the null hypothesis that the E85 subsidy contains a unit root but can reject the null hypothesis of a unit root for wholesale E85 prices when we include two and four lags in the ADF test.

We also report the average rejection rates from station-by-station Engle-Granger cointegration tests between each station's E85 prices, the RIN subsidy, and wholesale E85 costs. When we include two and four lags, around 3% of tests reject the null hypothesis of no cointegration. When we include six lags, about 1% of the tests are rejected. Thus, while the prices appear to contain a unit root, we do not have strong evidence that stations' prices exhibit a long-run relationship with the E85 subsidy and wholesale E85 prices.

B Robustness

We explore the robustness of our results in several ways. First, we split our sample to examine whether stations that report prices to OPIS less regularly have different pass-through rates than stations that consistently report prices. Second, we divide our sample by zip codes classified the USDA as metropolitan versus micropolitan, small town, or rural based on 2010 Census commuting and population data. Third, we report results from two instrumental variables strategies to test the sensitivity of our findings to endogeneity concerns. Last, given previous findings in the literature, we explore whether pass-through of each upstream cost is asymmetric.

Pass-Through and Stations' Price Reporting Frequency. OPIS collects price data from retail fuel stations through a combination of reported fleet credit card swipes, phone surveys, and direct station feeds. Our results may be biased if fleets are more likely to fill up when E85 prices are lowest or if stations report E85 prices when sales are highest. Our market power results may also be biased if stations further from competitors report prices less frequently than stations with nearby competitors and reporting is correlated with E85 prices.[1] To test this, Panel A of Tables B.1 and B.2 present separate pass-through results for stations that report more than two years of price data and stations that report less than two years of price data. Average E85 wholesale cost pass-through is similar between the two groups. However, average subsidy pass-through does appear to be lower for stations reporting less than two years of data, though the difference does not hold across all specifications. While average pass-through rates are different between the two groups, our market power results are largely the same across the two samples. Branded major stations have lower subsidy pass-through, major retailers have higher subsidy pass through, and stations in more isolate markets have lower pass-through in both samples.

Urban-Rural Divide and Pass-Through. Last, we split our sample into rural and urban zip codes to ensure our results are not driven by stations in urban locations having higher pass-through than rural stations. We use zip code classifications from the USDA that classify areas as metropolitan, micropolitan, small town, and rural based on local commuting patterns and population statistics from the 2010 Census. Panel B of Tables B.1 and B.2 present our results. With few

[1] Our main specifications partially address these concerns by including station fixed effects. Despite this, stations that report prices less frequently may be systematically different than those that report prices more often in ways that are time-varying.

exceptions, stations in metropolitan areas and micropolitan, small towns, and rural areas have similar subsidy and wholesale cost pass-through rates. Also, stations in both areas have similar market structure results. Stations in micropolitan, small towns, and rural areas have higher pass-through rates if they are unbranded, a major retailer, or close to another station offering E85.

Instrumental Variables. An important threat to our identification strategy is endogeneity of the E85 subsidy and wholesale E85 prices. Consistent estimation of equation (3) requires that all the variables $\mathbf{X}_t$ and their lagged values are exogenous to the error term, i.e., $E(\epsilon_{it}|\mathbf{X}_t, \mathbf{X}_{t-1}, \mathbf{X}_{t-2}, \cdots) = 0$. The assumption is violated if contemporaneous and historical RIN prices and wholesale fuel costs are correlated with local E85 demand conditions. We use two instrumental variables strategy to assess the robustness of our results to such concerns. First, we assume that only contemporaneous values of $\mathbf{X}_t$ are endogenous, i.e., $E(\epsilon_{it}|\mathbf{X}_{t-1}, \mathbf{X}_{t-2}, \cdots) = 0$. In this case, short-run E85 demand shocks may be correlated with contemporaneous RIN and wholesale market prices; however, they are not correlated with lagged prices. Second, we assume all current and lagged values of $\mathbf{X}$ are endogenous.

We use weekly average, prompt-month CME Brent crude oil futures prices downloaded from Quandl as an instrument for wholesale E85 prices. Brent is as a benchmark world crude oil price and is, therefore, not affected by market conditions in the U.S. Midwest. We use indicator variables for the week of and up to two weeks following each RFS policy development highlighted in Figure 3a as instruments for the E85 subsidy. The policy announcements shifted industry expectations regarding whether the mandates would be above or below the blend wall and led to significant changes in RIN prices. So long as the announcements timing was exogenous to E85 market conditions, RIN price changes (conditional on wholesale E85 prices and month fixed effects) around the weeks following each announcement are valid instruments. This condition is likely satisfied since the enacting legislation and requirements to address stakeholder comments guide the timing of the EPA's announcements.

Table B.3 presents the estimated pass-through rates after eight weeks for the two instrumental variables strategies. The top panel presents estimates for the specifications instrumenting for contemporaneous and lagged wholesale prices. The bottom panel shows results instrumenting only for contemporaneous subsidy and wholesale fuel prices. We present estimates for the OLS model and CDM models in levels and first-differences, with and without month fixed effects. For the OLS model, we use contemporaneous Brent crude oil prices and indicators for the week in which a policy event occurred. For the CDM models, we include up to eight lags of the Brent crude oil price and indicators for up to two weeks after each policy even occurred. All standard errors are clustered by fuel station and year-month and include a small sample adjustment of the covariance matrix. We report Kleibergen-Paap F-statistics from the first stage regression at the bottom of each panel.

Results are mostly similar to our main results using either IV strategy. E85 wholesale costs are fully passed through in all models except the first-differences CDM models. The E85 subsidy pass-through coefficients range between 40% and 82%, depending on the specification. In many cases, the first stage F-statistics are small, particularly given that the number of instrumented variables is large. Thus, we interpret the results with caution, instead offering them as evidence that endogeneity is not a significant concern in our setting.

Asymmetric Pass-Through. Last, we consider whether retail E85 prices respond asymmetrically to E85 subsidy and wholesale fuel cost changes. To test this, we estimate the following model:

$$\Delta Y_{it} = \alpha_i + \sum_{j=0}^{L} \beta_j^{+} \Delta \mathbf{X}_{t-j}^{+} + \sum_{j=0}^{L} \beta_j^{-} \Delta \mathbf{X}_{t-j}^{-} + \gamma_\tau + \epsilon_{it},$$

where,

$$\Delta X_t^{+} = \max\{0, \Delta X_t\}, \quad \Delta X_t^{-} = \min\{0, \Delta X_t\}.$$

Figure B.1 graphs the cumulative pass-through rates for decreases and increases in each upstream cost. All else equal, E85 prices increase more rapidly when the E85 subsidy falls than they decrease when the subsidy increases. We also estimate that retail E85 prices are more responsive to decreases in E85 wholesale costs than increases. The result may be driven by drivers' demand for the fuel increasing as its price falls, and station owners, therefore, purchasing the fuel more from local wholesale fuel terminals. However, both asymmetric responses are estimated with a high degree of uncertainty, and drawing firm conclusions from the results are difficult.

Table A.1: Stationarity and Cointegration Test Results

		Fisher Inv. χ^2 (Trend)		
		2 Lags	4 Lags	6 Lags
	p-value	0.2389	0.339	0.9971
		Fisher Inv. χ^2 (Trend, Demeaned)		
Retail E85 Prices		2 Lags	4 Lags	6 Lags
	p-value	<0.000	<0.000	0.8985
		Station ADF (Trend)		
		2 Lags	4 Lags	6 Lags
	% Reject	0.068	0.049	0.051
		ADF (Trend)		
E85 Subsidy		2 Lags	4 Lags	6 Lags
	MacKinnon p-value	0.237	0.347	0.137
		ADF (Trend)		
Wholesale E85		2 Lags	4 Lags	6 Lags
	MacKinnon p-value	0.038	0.060	0.244
		Engle-Granger (Trend)		
Station-Cointegration		2 Lags	4 Lags	6 Lags
	% Reject	0.034	0.025	0.012

Notes: The top panel presents both panel and station-level unit root test results. The p-values for the Fisher Inverse χ^2 panel unit root tests combine ADF test statistics for all stations' ADF tests. The null hypothesis of the Fisher test is that all stations' prices contain a unit root. The station ADF tests present the average 5% confidence level rejection rate of stations using an ADF test with the listed number of lags. For the subsidy and average E85 wholesale prices, MacKinnon approximate p-values for an ADF test with the listed number of lags are reported. The null hypothesis of all ADF tests is that the series contains a unit root. The station-cointegration panel results present the average 5% confidence level rejection rate of station-level Engle-Granger cointegration tests between each station's E85 prices and the wholesale E85 price. The null hypothesis is that the series are not cointegrated.

Table B.1: Long-Run E85 Cost Pass-Through: Robustness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Observations per Station								
E85 Subsidy (\$/gal)	0.379***	0.543***	0.587***	0.808***	0.656***	0.622***	0.489***	0.804***
	(0.091)	(0.085)	(0.138)	(0.061)	(0.178)	(0.119)	(0.136)	(0.103)
E85 Wholesale (\$/gal)	0.997***	0.998***	0.953***	0.975***	0.924***	0.767***	0.850***	0.710***
	(0.038)	(0.026)	(0.046)	(0.018)	(0.094)	(0.089)	(0.141)	(0.063)
H_0: $\beta_L^\tau = 1$	0.000	0.000	0.005	0.003	0.061	0.003	0.001	0.064
H_0: $\beta_L^e = 1$	0.948	0.950	0.311	0.177	0.425	0.012	0.296	0.000
Observations	4,782	11,990	4,782	11,990	4,324	11,589	4,324	11,589
N (Stations)	299	113	299	113	298	113	298	113
Sample	$<$ 2 Yrs	$\geq$ 2 Yrs	$<$ 2 Yrs	$\geq$ 2 Yrs	$<$ 2 Yrs	$\geq$ 2 Yrs	$<$ 2 Yrs	$\geq$ 2 Yrs
Panel B: Metropolitan vs. Micropolitan/Rural Area								
E85 Subsidy (\$/gal)	0.517***	0.537***	0.807***	0.755***	0.673***	0.528***	0.828***	0.670***
	(0.085)	(0.079)	(0.062)	(0.074)	(0.139)	(0.095)	(0.122)	(0.100)
E85 Wholesale (\$/gal)	0.980***	1.033***	0.951***	1.005***	0.848***	0.722***	0.768***	0.593***
	(0.026)	(0.024)	(0.019)	(0.021)	(0.088)	(0.096)	(0.058)	(0.063)
H_0: $\beta_L^\tau = 1$	0.000	0.000	0.004	0.002	0.024	0.000	0.166	0.002
H_0: $\beta_L^e = 1$	0.442	0.190	0.016	0.831	0.093	0.006	0.000	0.000
Observations	10,929	5,843	10,929	5,843	10,368	5,545	10,368	5,545
N (Stations)	266	146	266	146	266	145	266	145
Sample	Metro	Micro/Rural	Metro	Micro/Rural	Metro	Micro/Rural	Metro	Micro/Rural
Model	CDM	CDM	CDM	CDM	CDM	CDM	CDM	CDM
Specification	Level	Level	Level	Level	FD	FD	FD	FD
Lags (Weeks)	8	8	8	8	8	8	8	8
Station FE	Yes	Yes	Yes	Yes	No	No	No	No
Month FE	No	No	Yes	Yes	No	No	Yes	Yes

Notes: The dependent variable is the retail E85 price (\$/gal). The CDM model columns present the cumulative dynamic multipliers for each variable after eight weeks. H_0: $\beta_L^\tau = 1$ and H_0: $\beta_L^e = 1$ present p-values from a test of complete pass-through of the RIN subsidy and E85 wholesale costs after eight weeks, respectively. Standard errors are two-way clustered at the station and year-by-month. *, **, *** denotes significance at the 10%, 5%, and 1% level.

Table B.2: Long-Run E85 Pass-Through and Market Structure: Robustness

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Observations per Station						
E85 Subsidy ($/gal):	0.690***	0.832***	0.434***	0.726***	0.564***	0.846***
	(0.140)	(0.106)	(0.118)	(0.103)	(0.178)	(0.108)
× Branded Major	-0.356**	-0.123				
	(0.162)	(0.130)				
× Major Retailer			0.183	0.123		
			(0.281)	(0.140)		
× > 10 mi. to Competitor					-0.149	-0.185**
					(0.196)	(0.077)
E85 Wholesale Cost ($/gal):	0.937***	0.722***	0.756***	0.633***	0.879***	0.729***
	(0.223)	(0.070)	(0.154)	(0.075)	(0.149)	(0.062)
× Branded Major	-0.121	-0.046				
	(0.248)	(0.070)				
× Major Retailer			0.135	0.119		
			(0.102)	(0.072)		
× > 10 mi. to Competitor					-0.121	-0.086**
					(0.104)	(0.040)
Observations	4,324	11,589	4,324	11,589	4,324	11,589
N (Stations)	298	113	298	113	298	113
Sample	$<$ 2 Yrs	$\geq$ 2 Yrs	$<$ 2 Yrs	$\geq$ 2 Yrs	$<$ 2 Yrs	$\geq$ 2 Yrs
Panel B: Metropolitan vs. Micropolitan/Rural Area						
E85 Subsidy ($/gal):	0.872***	0.707***	0.742***	0.620***	0.841***	0.755***
	(0.118)	(0.114)	(0.124)	(0.101)	(0.128)	(0.102)
× Branded Major	-0.174	-0.096				
	(0.232)	(0.116)				
× Major Retailer			0.125	0.103		
			(0.182)	(0.103)		
× > 10 mi. to Competitor					-0.107	-0.177**
					(0.075)	(0.087)
E85 Wholesale Cost ($/gal):	0.754***	0.646***	0.757***	0.510***	0.772***	0.626***
	(0.069)	(0.070)	(0.082)	(0.072)	(0.059)	(0.062)
× Branded Major	0.130	-0.135**				
	(0.120)	(0.065)				
× Major Retailer			0.022	0.167**		
			(0.085)	(0.063)		
× > 10 mi. to Competitor					-0.015	-0.075
					(0.046)	(0.052)
Observations	10,368	5,545	10,368	5,545	10,368	5,545
N (Stations)	266	145	266	145	266	145
Sample	Metro	Micro/Rural	Metro	Micro/Rural	Metro	Micro/Rural

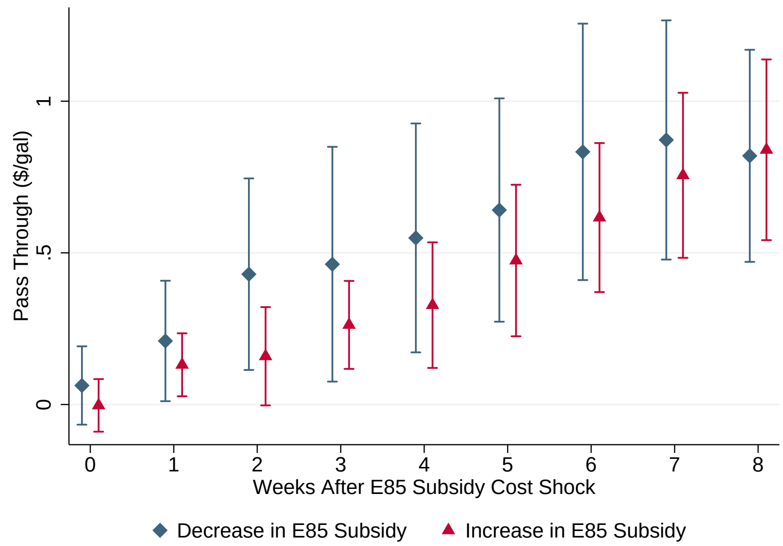
Notes: The dependent variable is the retail E85 price ($/gal). All results are from a model estimated in first-differences with month fixed effects. "× Branded Major" is an indicator variable for whether a station is affiliated with a large, vertically integrated oil company. "× Major Retailer" is an indicator for whether the station is affiliated with a large, independent gasoline retail company. "× > 10 mi. to Competitor" is an indicator that equals 1 if the closest competitor selling E85 is more than 10 miles away. Standard errors are robust to heteroskedasticity and clustering at the station and month-by-year level. *, **, *** denotes significance at the 10%, 5%, and 1% level.

Table B.3: E85 Subsidy Pass-Through: Instrumental Variables Estimation

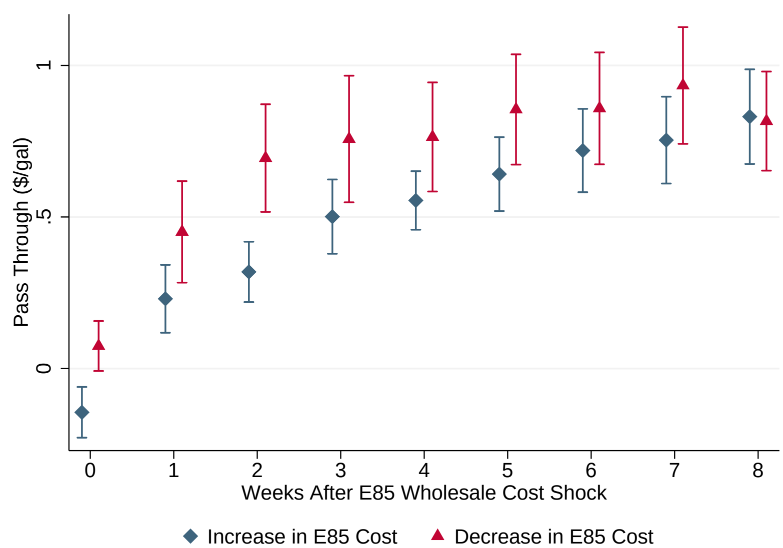
	(1)	(2)	(3)	(4)	(5)
Panel A: Contemporaneous and Lagged Values Endogenous					
E85 Subsidy ($/gal)	0.428**	0.555***	0.670***	0.824**	0.519**
	(0.178)	(0.154)	(0.122)	(0.331)	(0.227)
E85 Wholesale Costs ($/gal)	1.032***	0.985***	0.948***	0.799**	0.566**
	(0.038)	(0.031)	(0.033)	(0.395)	(0.252)
Kleibergen-Paap F statistic	23.208	0.473	0.109	0.767	0.159
Observations	29,938	15,880	15,880	15,096	15,096
Panel B: Contemporaneous Values Endogenous					
E85 Subsidy ($/gal)	0.428**	0.459***	0.656***	0.623***	0.707***
	(0.178)	(0.096)	(0.105)	(0.119)	(0.136)
E85 Wholesale Costs ($/gal)	1.032***	0.980***	0.951***	0.819***	0.575***
	(0.038)	(0.030)	(0.026)	(0.101)	(0.159)
Kleibergen-Paap F statistic	23.208	2.013	2.228	51.282	4.761
Observations	29,938	16,772	16,772	15,913	15,913
Model	OLS	CDM	CDM	CDM	CDM
Specification	Level	Level	Level	FD	FD
Lags (Weeks)	N/A	8	8	8	8
Station FE	Yes	Yes	Yes	No	No
Month FE	Yes	No	Yes	No	Yes

Notes: The dependent variable is the retail E85 price ($/gal). The top panel presents estimates from our IV model that assumes all contemporaneous and lagged prices are endogenous, and the bottom panel presents estimates from our IV model assuming only contemporaneous prices are endogenous. Standard errors are robust to heteroskedasticity and are two-way clustered at the station and year-by-month. *, **, *** denotes significance at the 10%, 5%, and 1% level.

Figure B.1: Pass-Through of Upstream Costs to Retail E85 Prices: Asymmetric Responses



(a) E85 Subsidy



(b) Wholesale E85

Notes: The figure graphs the average speed with which a shock to the upstream E85 subsidy and E85 wholesale costs are reflected in retail E85 prices. The coefficients are estimated separately for increases and decreases in each cost variable. All cost shocks occur in week 0.

References

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