

Web Appendix

Clearing the Air? The Effects of Gasoline Content Regulation on Air Quality

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Table A1: Reid vapor pressure (RVP) phase I regulatory details

RVP level (psi) ¹	States
10.5	DE, DC, FL, ID, IL (northern), IN, IA, KY, ME, MD, MI, MN, MT, NE, NH, ND, OH, OR, PA, SD, VT, WA, WA, WV, WI, WY
10.5 Jun/Sep; 9.5 Jul/Aug	AL, AR, GA, IL (southern), KS, LA, MS, MO, NC, SC, TN
9.5	CA, CO, NV, OK, TX (eastern, except Dallas area), UT
9.5 Sep, 9.0 Jun-Aug	AZ, NM, TX (western)
9.0 ²	CT, MA, NJ, NY, TX (Dallas area), RI

¹The RVP control season for retail gasoline distribution stations is June 1 - September 15. Refiners and wholesale terminals must comply by May 1. RVP phase I covers the summers of 1989-1991.

²These areas had been assigned higher RVP limits by the EPA's RVP rule, but elected to observe a tighter limit as part of their State Implementation Plans to achieve the ozone air quality standard

Table A2: Reid vapor pressure (RVP) phase II regulatory details

Area	Number of Counties	RVP First Year	RVP Last Year	VOC Control Period ¹		RVP level (psi)
				Seasonal Start Date	Seasonal End Date	
<i>Federally mandated</i>						
Birmingham, AL	2	1992	1997 ²	01 Jun	15 Sep	7.8
Phoenix, AZ	1	1992	1997 ³	01 Jun	15 Sep	7.8
Denver, CO	6	1992		01 Jun	15 Sep	7.8
Washington, DC-MD-VA ⁴	17	1992	1994 ⁵	01 Jun	15 Sep	7.8
Ft. Lauderdale-Miami, FL	6	1992		01 Jun	15 Sep	7.8
Atlanta, GA	13	1992	1998 ²	01 Jun	15 Sep	7.8
Kansas City, KS	2	1992	1996 ²	01 Jun	15 Sep	7.8
Baton Rouge-New Orleans, LA	17	1992		01 Jun	15 Sep	7.8
Baltimore, MD ⁴	6	1992	1994 ⁵	01 Jun	15 Sep	7.8
Kansas City, MO	3	1992	1996 ²	01 Jun	15 Sep	7.8
St. Louis, MO ⁴	5	1992	1998 ⁵	01 Jun	15 Sep	7.8
Greensboro-Raleigh, NC	9	1992		01 Jun	15 Sep	7.8
Reno-Sparks, NV	1	1992		01 Jun	15 Sep	7.8
Portland, OR	5	1992		01 Jun	15 Sep	7.8
Knoxville, TN	1	1992	1993 ⁶	01 Jun	15 Sep	7.8
Memphis & Nashville, TN	6	1992		01 Jun	15 Sep	7.8
Beaumont, TX	3	1992		01 Jun	15 Sep	7.8
Dallas & Houston, TX	12	1992	1994 ⁵	01 Jun	15 Sep	7.8
El Paso, TX	1	1992	1995 ²	01 Jun	15 Sep	7.8
Victoria, TX	1	1992	1999 ²	01 Jun	15 Sep	7.8
Salt Lake City, UT	2	1992		01 Jun	15 Sep	7.8
Norfolk, VA ⁴	11	1992	1994 ⁵	01 Jun	15 Sep	7.8
Richmond, VA ⁴	7	1992	1994 ⁵	01 Jun	15 Sep	7.8
White Top Mountain, VA	1	1992		01 Jun	15 Sep	7.8
All other areas		1992		01 Jun	15 Sep	9.0
<i>State Implementation Plans</i>						
Los Angeles-San Diego, CA	6	1992	1994 ⁵	01 May	31 Oct	7.8
Rest of state, CA	52	1992	1995 ⁷	varies ⁸	varies ⁸	7.8
Atlanta plus 12 addl. counties, GA	25	1999	2002	01 Jun	15 Sep	7.0 ⁹
Atlanta plus 32 addl. counties, GA	45	2003		01 Jun	15 Sep	7.0 ⁹
East St. Louis-Wood River, IL	3	1995		01 Jun	15 Sep	7.2
Jeffersonville, IN	2	1996		01 Jun	15 Sep	7.8
Kansas City, KS	2	1997	2000 ²	01 Jun	15 Sep	7.2
Kansas City, KS	2	2001		01 Jun	15 Sep	7.0
Bangor-Portland, ME	7	1999		01 May	15 Sep	7.8
Detroit, MI	7	1996		01 Jun ¹⁰	15 Sep	7.8
Kansas City, MO	3	1997	2000 ²	01 Jun	15 Sep	7.2
Kansas City, MO	3	2001		01 Jun	15 Sep	7.0
Pittsburgh, PA	7	1998		01 Jun	15 Sep	7.8
Eastern TX (excl. Dallas & Houston)	95	2000		01 May	01 Oct	7.8
El Paso, TX	1	1996		01 Jun	15 Sep	7.0

¹Indicated control period represents compliance date for retail gasoline distribution stations. Refiners and wholesale terminals must comply one month prior to indicated date.

²Adopted more stringent RVP program in the following summer as part of a State Implementation Plan (also indicated further below in table).

³Phoenix adopted RFG on 4 August, 1997.

⁴Baltimore, Washington DC, St. Louis, and several cities in Virginia are not parts of counties, and are treated as if they are separate counties in this table and the analysis.

⁵Adopted RFG in the following summer.

⁶Designated attainment following summer 1993

⁷Adopted CARB in the following summer.

⁸Seasonal start and end dates are county-specific.

⁹GA gasoline also restricts sulfur content

¹⁰RVP did not begin until 1 July in 1996.

Table A3: Reformulated gasoline (RFG) regulatory details

Area	Number of Counties	RFG First Year	RFG Last Year	VOC Control Period ¹	
				Seasonal Start Date	Seasonal End Date
<i>Federally mandated</i>					
Los Angeles-San Diego, CA	6	1995	1996 ²	01 Jun	15 Sep
Hartford, CT	6	1995		01 Jun	15 Sep
Chicago-Gary, IL-IN ³	10	1995		01 Jun	15 Sep
Baltimore, MD ⁴	6	1995		01 Jun	15 Sep
New York, NY-CT-NJ	25	1995		01 Jun	15 Sep
Philadelphia, PA-DE-MD-NJ	14	1995		01 Jun	15 Sep
Houston, TX	8	1995		01 Jun	15 Sep
Milwaukee, WI	6	1995		01 Jun	15 Sep
<i>Opt-in</i>					
Phoenix, AZ	1	1997 ⁵	1998 ⁵	01 Jun	30 Sep
Rest of state, CT	6	1995		01 Jun	15 Sep
Washington, DC-MD-VA ⁴	17	1995		01 Jun	15 Sep
Rest of state, DE	entire state	1995		01 Jun	15 Sep
Cincinnati-Hamilton, KY	3	1995		01 Jun	15 Sep
Louisville, KY	3	1995		01 Jun	15 Sep
Entire state, MA	14	1995		01 Jun	15 Sep
Bangor-Portland, ME	7	1995	1998 ⁶	01 Jun	15 Sep
St. Louis, MO ⁴	5	1999		01 Jun	15 Sep
Boston-Lawrence-Worcester, NH	4	1995		01 Jun	15 Sep
Rest of state, NJ	3	1995		01 Jun	15 Sep
Essex, NY	2	1995		01 Jun	15 Sep
Entire state, RI	5	1995		01 Jun	15 Sep
Dallas-Ft. Worth, TX	4	1995		01 Jun	15 Sep
Norfolk, VA ⁴	11	1995		01 Jun	15 Sep
Richmond, VA ⁴	7	1995		01 Jun	15 Sep
<i>State-specific reformulations</i>					
Phoenix, AZ (AZCBG)	1	1998		01 Jun	30 Sep
Entire state, CA (CARB)	58	1996		varies ⁷	varies ⁷

¹Indicated control period represents compliance date for gasoline distribution stations. Refiners and wholesale terminals must comply one month prior to indicated date.

²LA-San Diego area converted from federal RFG to CARB gasoline in March 1996 (concurrent with the conversion from federal RVP to CARB in the rest of CA). CARB regulations exceed federal RFG requirements.

³Chicago-area RFG is blended with 100% ethanol. RFG blendstock has a very low RVP of 5.5 psi.

⁴Baltimore, Washington DC, St. Louis, and several cities in Virginia are not parts of counties, and are treated as if they are separate counties in this table and the analysis.

⁵Phoenix (Maricopa County) adopted RFG on 04 Aug, 1997, and converted from federal RFG to Arizona Cleaner-Buring Gasoline (AZCBG) on 10 June, 1998.

⁶ME opted-out of RFG in March 1999 and adopted an RVP of 7.8 psi.

⁷Seasonal start and end dates are county-specific.

Table A4: Monitor-specific regression discontinuity estimation results for RVP and RFG

State	County	Monitor ID	Effect on log(ozone max)	Standard error	State	County	Monitor ID	Effect on log(ozone max)	Standard error
RVP Gasoline					RFG Gasoline				
Colorado	Adams	3001	0.055	(0.028) **	Arizona	Maricopa	19	-0.090	(0.044) **
Colorado	Arapahoe	2	0.100	(0.031) ***	Arizona	Maricopa	1004	-0.078	(0.032) **
Colorado	Denver	14	0.080	(0.040) **	Delaware	New Castle	1003	-0.116	(0.059) *
Colorado	Jefferson	2	0.035	(0.032)	District of Columbia		25	0.059	(0.060)
Florida	Broward	2003	-0.030	(0.031)	Illinois	Cook	50	-0.003	(0.050)
Florida	Broward	8002	-0.109	(0.032) ***	Illinois	Cook	64	-0.055	(0.047)
Florida	Duval	77	0.021	(0.025)	Illinois	Cook	7002	0.061	(0.030) **
Florida	Hillsborough	81	0.044	(0.034)	Illinois	DuPage	6001	0.027	(0.027)
Florida	Hillsborough	1035	0.009	(0.024)	Illinois	Kane	5	0.084	(0.029) ***
Florida	Miami-Dade	21	-0.115	(0.030) ***	Illinois	Lake	1002	3.4E-04	(0.037)
Florida	Miami-Dade	27	-0.078	(0.027) ***	Illinois	Lake	3001	-0.012	(0.037)
Florida	Miami-Dade	29	0.022	(0.034)	Illinois	Will	1008	0.073	(0.030) **
Florida	Miami-Dade	30	-0.105	(0.043) **	Maryland	Baltimore	3001	-0.052	(0.043)
Florida	Palm Beach	2004	-0.109	(0.112)	Maryland	Harford	1001	-0.036	(0.025)
Florida	Pinellas	4	-0.014	(0.027)	Massachusetts	Hampden	8	-0.019	(0.042)
Florida	Pinellas	18	-0.046	(0.038)	Massachusetts	Hampshire	4002	-0.029	(0.027)
Florida	Pinellas	5002	-0.070	(0.035) **	New Jersey	Atlantic	5	-0.134	(0.026) ***
Illinois	Madison	8	0.024	(0.032)	New Jersey	Camden	3	-0.039	(0.034)
Illinois	Madison	1009	0.014	(0.036)	New Jersey	Camden	1001	-0.147	(0.031) ***
Illinois	Madison	2007	0.026	(0.027)	New Jersey	Cumberland	7	-0.116	(0.025) ***
Illinois	Madison	3007	0.004	(0.026)	New Jersey	Gloucester	2	-0.100	(0.029) ***
Illinois	Saint Clair	10	0.068	(0.031) **	New Jersey	Hudson	6	-0.029	(0.029)
Louisiana	Beauregard	2	0.009	(0.054)	New Jersey	Hunterdon	1	-0.030	(0.033)
Louisiana	Calcasieu	2	-0.011	(0.057)	New Jersey	Mercer	5	-0.117	(0.041) ***
Louisiana	East Baton Rouge	3	0.025	(0.039)	New Jersey	Monmouth	5	-0.056	(0.028) **
Louisiana	East Baton Rouge	1001	-0.013	(0.037)	New Jersey	Morris	3001	-0.065	(0.034) *
Louisiana	Grant	1	0.009	(0.035)	New York	Dutchess	7	-0.029	(0.031)
Louisiana	Jefferson	1001	0.154	(0.042) ***	New York	Essex	2	-0.082	(0.023) ***
Louisiana	Orleans	12	-0.058	(0.047)	New York	Essex	3	-0.065	(0.023) ***
Louisiana	Pointe Coupee	1	-0.024	(0.033)	New York	New York	63	-0.078	(0.050)
Louisiana	St. Bernard	2	-0.077	(0.048)	New York	Suffolk	2	-0.073	(0.032) **
Louisiana	St. James	2	-0.044	(0.069)	Pennsylvania	Philadelphia	24	0.061	(0.029) **
Louisiana	St. Mary	3	0.049	(0.054)	Texas	Galveston	1002	0.001	(0.066)
Louisiana	West Baton Rouge	1	-0.056	(0.039)	Texas	Harris	46	0.001	(0.045)
Nevada	Washoe	20	0.040	(0.029)	Texas	Harris	47	0.018	(0.043)
Nevada	Washoe	1005	0.035	(0.032)	Texas	Harris	62	0.016	(0.053)
Tennessee	Davidson	11	0.068	(0.045)	Texas	Harris	1035	0.022	(0.048)
Tennessee	Davidson	26	-0.022	(0.051)	Texas	Tarrant	1002	0.219	(0.032) ***
Texas	Bexar	32	-0.013	(0.057)	Texas	Tarrant	2003	0.111	(0.034) ***
Texas	El Paso	37	0.088	(0.033) ***	Virginia	Fairfax	1004	8.4E-05	(0.056)
Texas	Gregg	1	0.019	(0.031)	Virginia	Fairfax	5001	0.028	(0.051)
Texas	Jefferson	9	-0.101	(0.066)					
Texas	Jefferson	11	0.087	(0.065)					
Texas	Nueces	25	-0.016	(0.047)					
Texas	Nueces	26	-0.030	(0.054)					
Texas	Travis	14	0.049	(0.038)					

Effects shown are the monitor-specific estimated coefficients on the treatment dummies of the regression discontinuity specification (3)

Standard errors are clustered on year-season

Estimated effects of RVP phase II (less than or equal to 7.8 psi) and federal RFG are relative to the baseline of a 9.0 psi RVP standard

Sample uses data from all seasons of 1989-2003

* significant at 10%; ** significant at 5%; *** significant at 1%

Table A4 continued: Monitor-specific regression discontinuity estimation results for CARB

State	County	Monitor ID	Effect on log(ozone max)	Standard error	State	County	Monitor ID	Effect on log(ozone max)	Standard error
CARB Gasoline					CARB Gasoline				
California	Alameda	3	0.140	(0.055) **	California	San Bernardino	5	-0.079	(0.066)
California	Alameda	5	0.025	(0.075)	California	San Bernardino	12	-0.049	(0.048)
California	Alameda	1001	0.066	(0.064)	California	San Bernardino	1004	-0.314	(0.134) **
California	Butte	2	0.079	(0.098)	California	San Bernardino	2002	-0.207	(0.063) ***
California	Contra Costa	2	0.093	(0.048) *	California	San Bernardino	4003	-0.074	(0.061)
California	Contra Costa	1002	0.057	(0.059)	California	San Bernardino	9004	-0.023	(0.030)
California	Contra Costa	3001	0.236	(0.044) ***	California	San Diego	1	-0.225	(0.078) ***
California	Fresno	7	0.193	(0.065) ***	California	San Diego	3	-0.135	(0.056) **
California	Fresno	4001	0.191	(0.091) **	California	San Diego	5	-0.231	(0.081) ***
California	Kern	7	-0.118	(0.057) **	California	San Diego	6	-0.064	(0.076)
California	Kern	8	0.007	(0.059)	California	San Diego	1001	-0.209	(0.064) ***
California	Kern	232	0.064	(0.061)	California	San Diego	1002	-0.127	(0.048) ***
California	Kern	5001	0.088	(0.060)	California	San Diego	1006	-0.119	(0.063) *
California	Kern	6001	0.061	(0.065)	California	San Diego	1007	-0.099	(0.067)
California	Lake	3001	0.002	(0.092)	California	San Francisco	5	-0.010	(0.079)
California	Los Angeles	2	-0.145	(0.083) *	California	San Joaquin	1002	0.062	(0.080)
California	Los Angeles	16	-0.130	(0.089)	California	San Luis Obispo	2001	-0.051	(0.049)
California	Los Angeles	113	-0.325	(0.111) ***	California	San Luis Obispo	2002	-0.149	(0.075) **
California	Los Angeles	1002	-0.325	(0.133) **	California	San Luis Obispo	3001	0.040	(0.039)
California	Los Angeles	1103	-0.446	(0.116) ***	California	San Luis Obispo	8001	-0.023	(0.041)
California	Los Angeles	1201	-0.108	(0.109)	California	San Mateo	1001	-0.148	(0.107)
California	Los Angeles	1301	-0.007	(0.153)	California	Santa Barbara	8	-0.047	(0.046)
California	Los Angeles	1601	-0.375	(0.086) ***	California	Santa Barbara	10	-0.203	(0.080) **
California	Los Angeles	1701	-0.434	(0.127) ***	California	Santa Barbara	1013	-0.022	(0.047)
California	Los Angeles	2005	-0.276	(0.071) ***	California	Santa Barbara	1014	-0.027	(0.065)
California	Los Angeles	4002	-0.084	(0.126)	California	Santa Barbara	1018	0.058	(0.053)
California	Los Angeles	5001	-0.115	(0.078)	California	Santa Barbara	1021	-0.030	(0.044)
California	Los Angeles	6002	-0.285	(0.063) ***	California	Santa Barbara	1025	-0.079	(0.057)
California	Marin	1	0.172	(0.060) ***	California	Santa Barbara	2004	-0.140	(0.047) ***
California	Monterey	2	-0.011	(0.043)	California	Santa Barbara	3001	-0.060	(0.046)
California	Napa	3	0.002	(0.055)	California	Santa Barbara	4003	0.065	(0.083)
California	Orange	1	-0.073	(0.117)	California	Santa Clara	4	0.040	(0.082)
California	Orange	2001	0.129	(0.079)	California	Santa Clara	1001	0.017	(0.080)
California	Orange	5001	-0.211	(0.081) ***	California	Santa Cruz	3	0.011	(0.047)
California	Riverside	2002	-0.360	(0.092) ***	California	Shasta	3003	-0.045	(0.044)
California	Riverside	5001	0.040	(0.037)	California	Solano	4	0.141	(0.051) ***
California	Riverside	6001	0.010	(0.073)	California	Sonoma	3	0.095	(0.058) *
California	Riverside	8001	-0.212	(0.045) ***	California	Stanislaus	5	0.102	(0.057) *
California	Riverside	9001	-0.028	(0.068)	California	Tulare	6	0.210	(0.064) ***
California	Sacramento	2	0.020	(0.085)	California	Tulare	2002	0.008	(0.059)
California	Sacramento	6	-0.190	(0.092) **	California	Ventura	4	-0.050	(0.062)
California	Sacramento	10	-0.060	(0.085)	California	Ventura	5	-0.142	(0.046) ***
California	San Benito	2	0.068	(0.037) *	California	Ventura	2002	-0.353	(0.086) ***
California	San Benito	3	-0.014	(0.040)	California	Ventura	2003	-0.006	(0.073)
California	San Bernardino	1	-0.012	(0.083)	California	Ventura	3001	-0.103	(0.100)

Effects shown are the monitor-specific estimated coefficients on the treatment dummies of the regression discontinuity specification (3)

Standard errors are clustered on year-season

Estimated effects of CARB are relative to the baseline of a 9.0 psi RVP standard

Sample uses data from all seasons of 1989-2003

* significant at 10%; ** significant at 5%; *** significant at 1%

Table A5: Monitor-specific regression discontinuity estimation results for summer RFG and NO_x controls. Treatment effects shown are the impact on log(ozone max)

State	County	Monitor ID	Original regression		Control for NO _x installations			
			RFG treatment		RFG treatment		NO _x installations /100	
			Beta	Std error	Beta	Std error	Beta	Std error
Delaware	New Castle	1003	-0.116	(0.059) *	-0.001	(0.051)	-0.099	(0.041) **
New Jersey	Atlantic	5	-0.134	(0.026) ***	-0.079	(0.034) **	-0.044	(0.020) **
New Jersey	Camden	1001	-0.039	(0.034)	0.070	(0.054)	-0.091	(0.036) **
New Jersey	Camden	3	-0.147	(0.031) ***	-0.043	(0.040)	-0.084	(0.022) ***
New Jersey	Cumberland	7	-0.116	(0.025) ***	-0.063	(0.037) *	-0.042	(0.022) *
New Jersey	Gloucester	2	-0.100	(0.029) ***	-0.036	(0.041)	-0.051	(0.022) **
New Jersey	Hudson	6	-0.029	(0.029)	0.045	(0.042)	-0.059	(0.030) *
New Jersey	Hunterdon	1	-0.030	(0.033)	0.040	(0.047)	-0.057	(0.028) **
New Jersey	Mercer	5	-0.117	(0.041) ***	-0.008	(0.057)	-0.087	(0.029) ***
New Jersey	Monmouth	5	-0.056	(0.028) **	-0.011	(0.047)	-0.042	(0.030)
New Jersey	Morris	3001	-0.065	(0.034) *	0.021	(0.044)	-0.072	(0.022) ***
New York	Dutchess	7	-0.029	(0.031)	0.027	(0.037)	-0.051	(0.021) **
New York	Essex	2	-0.082	(0.023) ***	-0.047	(0.036)	-0.032	(0.023)
New York	Essex	3	-0.065	(0.023) ***	-0.086	(0.029) **	0.018	(0.018)
New York	New York	63	-0.078	(0.050)	-0.086	(0.088)	0.008	(0.063)
New York	Suffolk	2	-0.073	(0.032) **	-0.038	(0.047)	-0.029	(0.032)
Pennsylvania	Philadelphia	24	0.061	(0.029) **	0.112	(0.040) **	-0.042	(0.025) *

Effects shown are the monitor-specific estimated coefficients on the treatment variables discussed in section IV(B)

NO_x installations include those in Delaware, New Jersey, New York, and Pennsylvania, per table 5

Standard errors are clustered on year-season

Estimated effects of federal RFG are relative to the baseline of a 9.0 psi RVP standard

Sample uses data from all seasons of 1989-2003

* significant at 10%; ** significant at 5%; *** significant at 1%