

Assessing the Effect of Five Gasoline Properties on Exhaust Emissions from Light-Duty Vehicles certified to Tier-2 Standards

Analysis of Data from EPA Phase 3

(EPAct/V2/E-89)

Appendix G.5

Final Model Fitting

Oxides of Nitrogen (NO_x) (Bag 3)

No. Observations:	931
No. Vehicles:	15
No. censored measurements:	25
No. missing measurements:	2
No. measurements removed:	1
Model Type:	Tobit regression

G.5.1 Model Fitting based on the 11-term design model.

Models fit for NO_x (Bag 3): (Grand Intercept not fit by Tobit models).

Model Term	Notation	Model						
		Full	FM2 ¹	FM3	FM4	FM5	FM6	FM7
etOH	Z_e	•	•	•	•	•	•	•
Arom	Z_a	•	•	•	•	•	•	•
RVP	Z_r	•	•	•	•	•	•	•
T50	Z_5	•	•	•	•	•	•	×
T90	Z_9	•	•	•	•	•	•	•
etOH × etOH	ZZ_{ee}	•	×					
T50 × T50	ZZ_{55}	•	•	•	•	×		
etOH × Arom	ZZ_{ea}	•	•	•	×			
etOH × RVP	ZZ_{er}	•	×					
etOH × T50	ZZ_{e5}	•	•	•	•	•	×	
etOH × T90	ZZ_{e9}	•	•	×				

¹ Indicates “Full minus 2,” etc.

NO_x (Bag 3): Model fitting history, starting with the 11-term design model.

Fit Parameters			Test with respect to Previous Model		
Model	$p-1^1$	$-2\ln L$	Dev.	d	$\Pr > \chi^2$
Full Model	11	2809.349			
FM2	9	2809.676	0.327	2	0.849
FM3	8	2810.499	0.823	1	0.364
FM4	7	2811.808	1.309	1	0.253
FM5	6	2813.571	1.763	1	0.184
FM6	5	2815.925	2.354	1	0.125
FM7	4	2817.195	1.270	1	0.260

¹ Total number of terms excludes the intercept, as the Tobit models do not fit intercepts.

² Best fit with respect to the 16-term extended model.

NO_x (Bag 3): Coefficients and Tests of Effect for the Full and Reduced Models, with respect to the 11-term design model.

Effect	<i>Full Model</i>					<i>Reduced Model (FM7)</i>				
	Estimate	Std. Err.	d.f.	χ^2 - value	$\text{Pr}>\chi^2$	Estimate	Std. Err.	d.f.	χ^2 - value	$\text{Pr}>\chi^2$
Intercept ¹						-5.2561				
Z_e	0.06820	0.05120	1	1.77	0.18	0.1078	0.0348	1	9.59	0.0020
Z_a	0.06770	0.03570	1	3.59	0.058	0.0816	0.0350	1	5.42	0.020
Z_r	0.11760	0.04080	1	8.30	0.0040	0.1477	0.0356	1	17.2	<0.0001
Z_5	-0.05780	0.05140	1	1.26	0.26					
Z_9	0.06850	0.03570	1	3.68	0.055	0.0601	0.0353	1	2.90	0.089
ZZ_{ee}	-0.01240	0.06870	1	0.03	0.86					
ZZ_{55}	0.05010	0.05150	1	0.95	0.33					
ZZ_{ea}	-0.04210	0.03490	1	1.45	0.23					
ZZ_{er}	-0.02020	0.03570	1	0.32	0.57					
ZZ_{e5}	0.06420	0.07380	1	0.76	0.38					
ZZ_{e9}	0.03450	0.03510	1	0.97	0.33					
σ_{veh}^2 ¹						1.7619				
σ_{ε}^2	1.05310					1.05750				

¹ Not fit by Tobit model; calculated manually from individual vehicle intercepts.

G.5.2 Model Fitting based on the 16-term extended model.

Models fit for NO_x (Bag 3): (Grand Intercept not fit by Tobit models).

Model Term	Notation	Model						
		Full	FM4 ¹	FM5	FM6	FM7	FM8	FM9
etOH	Z_e	•	•	•	•	•	•	•
Arom	Z_a	•	•	•	•	•	•	•
RVP	Z_r	•	•	•	•	•	•	•
T50	Z_5	•	•	•	•	•	•	•
T90	Z_9	•	•	•	•	•	•	•
etOH × etOH	ZZ_{ee}	•	×					
T50 × T50	ZZ_{55}	•	•	•	•	•	•	×
etOH × Arom	ZZ_{ea}	•	•	×				
etOH × RVP	ZZ_{er}	•	•	•	•	×		
etOH × T50	ZZ_{e5}	•	•	•	•	•	•	•
etOH × T90	ZZ_{e9}	•	•	•	×			
T90 × T90	ZZ_{99}	•	•	•	•	•	•	•
Arom × RVP	ZZ_{ar}	•	×					
Arom × T50	ZZ_{a5}	•	•	•	•	•	•	•
Arom × T90	ZZ_{a9}	•	•	•	•	•	×	
T50 × T90	ZZ_{59}	•	×					
RVP × T90	ZZ_{r9}	•	×					

NO_x (Bag 3): Model fitting history, starting with the 17-term extended model.

Fit Parameters			Test with respect to Previous Model		
Model	$p-l^1$	$-2\ln L$	Dev.	d	$\Pr > \chi^2$
Full Model	16	2801.073			
FM4	12	2801.869	0.796	4	0.939
FM5	11	2802.472	0.603	1	0.437
FM6	10	2803.337	0.865	1	0.352
FM7	9	2804.295	0.958	1	0.328
FM8	8	2806.313	2.018	1	0.155
FM9	7	2808.530	2.217	1	0.136

¹ Total number of terms excludes the intercept, as the Tobit Models do not fit intercepts.

² Best fit with respect to the 17-term extended model.

NO_x (Bag 3): Coefficients and Tests of Effect for the Full and Reduced Models, with respect to the 16-term extended model.

Effect	<i>Full Model</i>					<i>Reduced Model (FM9)</i>				
	Estimate	Std. Err.	d.f.	χ^2 - value	$\text{Pr}>\chi^2$	Estimate	Std. Err.	d.f.	χ^2 - value	$\text{Pr}>\chi^2$
Intercept ¹						-5.255				
Z_e	0.0693	0.0616	1.0000	1.26	0.261	0.0884	0.0453	1	3.82	0.051
Z_a	0.0661	0.0387	1.0000	2.92	0.088	0.0667	0.0356	1	3.52	0.061
Z_r	0.1737	0.0520	1.0000	11.1	0.00080	0.1692	0.0420	1	16.2	<0.0001
Z_5	-0.0508	0.0686	1.0000	0.55	0.46	-0.0224	0.0488	1	0.21	0.65
Z_9	0.1007	0.0398	1.0000	6.39	0.012	0.0850	0.0366	1	5.39	0.020
ZZ_{ee}	-0.0220	0.0718	1.0000	0.09	0.76					
ZZ_{55}	0.0553	0.0586	1.0000	0.89	0.34					
ZZ_{ea}	0.0477	0.0581	1.0000	0.67	0.41					
ZZ_{er}	-0.0516	0.0394	1.0000	1.72	0.19					
ZZ_{e5}	0.0654	0.0758	1.0000	0.74	0.39	0.0637	0.0358	1	3.16	0.075
ZZ_{e9}	0.0464	0.0466	1.0000	0.99	0.32					
ZZ_{ar}	0.0254	0.0630	1.0000	0.16	0.69					
ZZ_{a5}	0.1624	0.0701	1.0000	5.36	0.021	0.0894	0.0398	1	5.05	0.025
ZZ_{a9}	-0.0444	0.0394	1.0000	1.27	0.26					
ZZ_{59}	0.0226	0.0524	1.0000	0.19	0.67					
ZZ_{r9}	0.0300	0.0446	1.0000	0.45	0.50					
σ_{veh}^2 ¹						1.7509				
σ_{ε}^2	1.0486					1.0527				

¹ Not fit by Tobit model.