

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.4

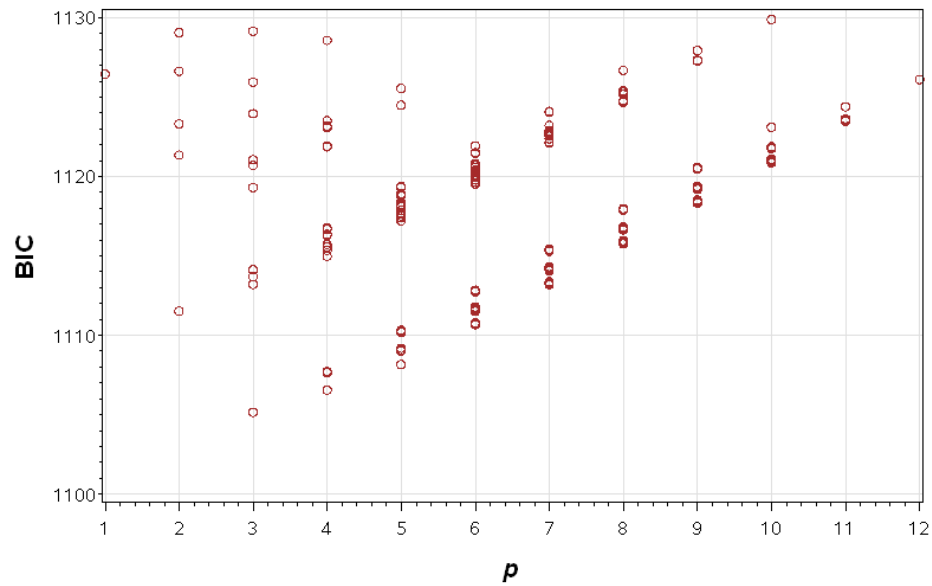
Final Model Fitting

Oxides of Nitrogen (NO_x) (Bag 2)

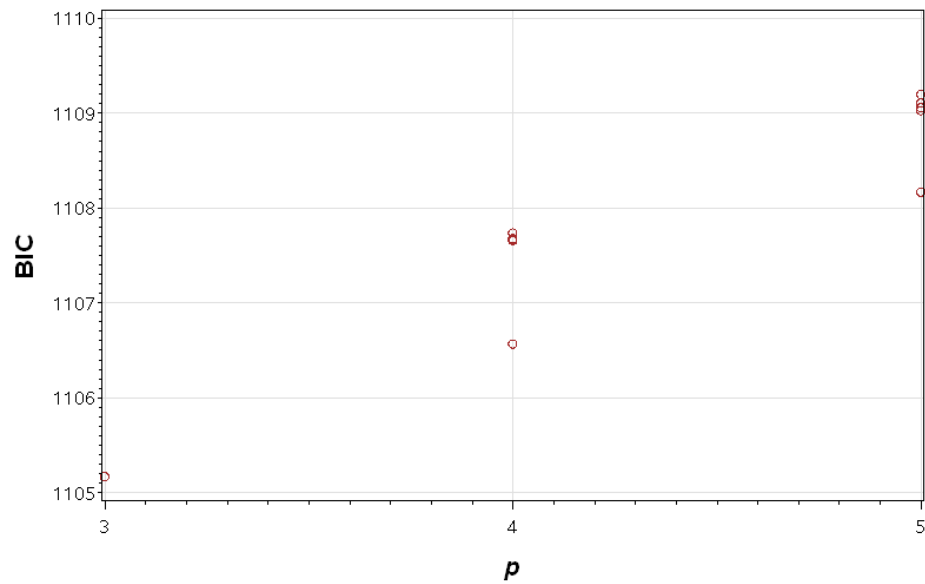
No. Observations:	893	
No. Vehicles:	14	(drop Cobalt)
No. censored measurements:	0	
No. missing measurements:	0	
No. measurements removed:	0	
Model Type:	Mixed model	

G.4.1 Model fitting with respect to the 11-term design model.

Design Model (11-terms): Bayesian Information Criterion (BIC) vs. number of terms in model (p) for all possible models respecting hierarchy.



Design Model (11-terms): Bayesian Information Criterion (BIC) vs. number of terms in model (p) for all possible models respecting hierarchy (CLOSEUP of previous figure).



NO_x (Bag 2): Number of terms (*p*), Goodness-of-fit (BIC) and terms included in the 35 best-fitting candidate models (out of a total of 294 possible models with hierarchy). (Terms included in models ranked 1-10 comprise the “superset” for final model-fitting).

Rank	<i>p</i>	BIC	Design Terms									
			etOH	Arom	RVP	T50	T90	etOH x etOH	T50 x T50	etOH x Arom	etOH x RVP	etOH x T50
1	3	1105.17	•	•								
2	4	1106.57	•	•	•							
3	4	1107.66	•	•		•						
4	4	1107.67	•	•			•					
5	4	1107.68	•	•					•			
6	4	1107.74	•	•			•					
7	5	1108.17	•	•	•					•		
8	5	1109.03	•	•	•		•					
9	5	1109.06	•	•	•			•				
10	5	1109.11	•	•	•				•			
11	5	1109.20	•	•	•	•						
12	5	1110.20	•	•		•	•					
13	5	1110.20	•	•		•			•			
14	5	1110.21	•	•			•		•			
15	5	1110.21	•	•		•					•	
16	5	1110.23	•	•		•	•					
17	5	1110.25	•	•			•	•				
18	5	1110.26	•	•			•		•			
19	5	1110.29	•	•		•			•			
20	5	1110.33	•	•			•					•
21	6	1110.68	•	•	•				•	•		
22	6	1110.69	•	•	•		•			•		
23	6	1110.71	•	•	•			•		•		
24	6	1110.81	•	•	•	•				•		
25	2	1111.53	•									
26	6	1111.53	•	•	•		•	•				
27	6	1111.58	•	•	•		•					•
28	6	1111.58	•	•	•		•		•			
29	6	1111.62	•	•	•			•	•			
30	6	1111.66	•	•	•	•	•					
31	6	1111.67	•	•	•	•	•					
32	6	1111.71	•	•	•	•			•			
33	6	1111.73	•	•	•	•			•			
34	6	1111.80	•	•	•	•					•	
35	6	1112.75	•	•		•			•		•	

Models fit for NO_x (Bag 2): (all models include an intercept term).

Model Term	Notation	Model		
		Superset	SM4 ¹	SM6
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 denotes “Superset minus 4,” etc.

NO_x (Bag 2): Model fitting history, starting with the 10-term superset model.

Fit Parameters				<i>Test with respect to Previous Model</i>		
Model	p	$-2\ln L$	BIC ¹	Dev.	d	$\Pr > \chi^2$
Superset	9	1089.365	1118.395			
SM4	5	1089.700	1108.173	0.335	4	0.987
SM6 ²	3	1091.971	1105.166	2.271		0.321

¹ A lower value indicates a better fit.

² Best fit with respect to the 11-term design model.

NO_x (Bag 2): Coefficients and Tests of Effect for the Superset and Reduced Models, with respect to the 11-term design model.

Effect	<i>Full Model (superset)</i>				
	Estimate	Std. Err.	d.f.	<i>t</i> -value	Pr> <i>t</i>
Intercept	-4.5680	0.1844	14	-24.8	0.00000
Z_e	0.05813	0.01952	879	2.98	0.0030
Z_a	0.04469	0.01492	879	3.00	0.0028
Z_r	-0.01729	0.01653	879	-1.05	0.30
Z_5	-0.00245	0.02024	879	-0.12	0.90
Z_9	0.00491	0.01481	879	0.33	0.74
ZZ_{ee}	-0.00447	0.01525	879	-0.29	0.77
ZZ_{55}	---	---	---	---	---
ZZ_{ea}	0.00478	0.01455	879	0.33	0.74
ZZ_{er}	0.01418	0.01455	879	0.97	0.33
ZZ_{e5}	---	---	---	---	---
ZZ_{e9}	---	---	---	---	---

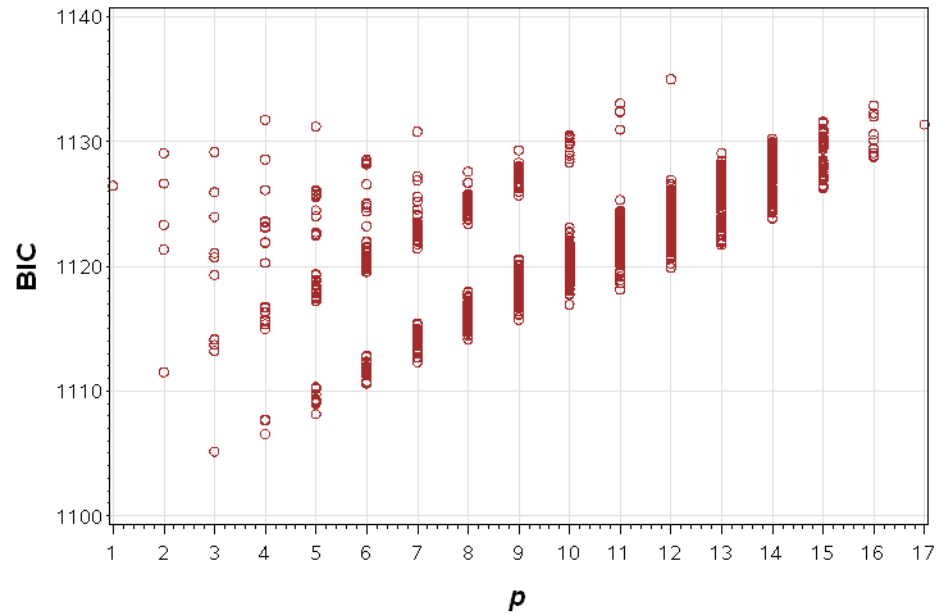
σ_{veh}^2	0.4730
σ_{ε}^2	0.1830

<i>Reduced Model (SM6)</i>				
Estimate	Std. Err.	d.f.	<i>t</i> -value	Pr> <i>t</i>
-4.5692	0.1842	14	-24.8	0.000000
0.06299	0.01444	879	4.36	0.000014
0.04407	0.01465	879	3.01	0.0027
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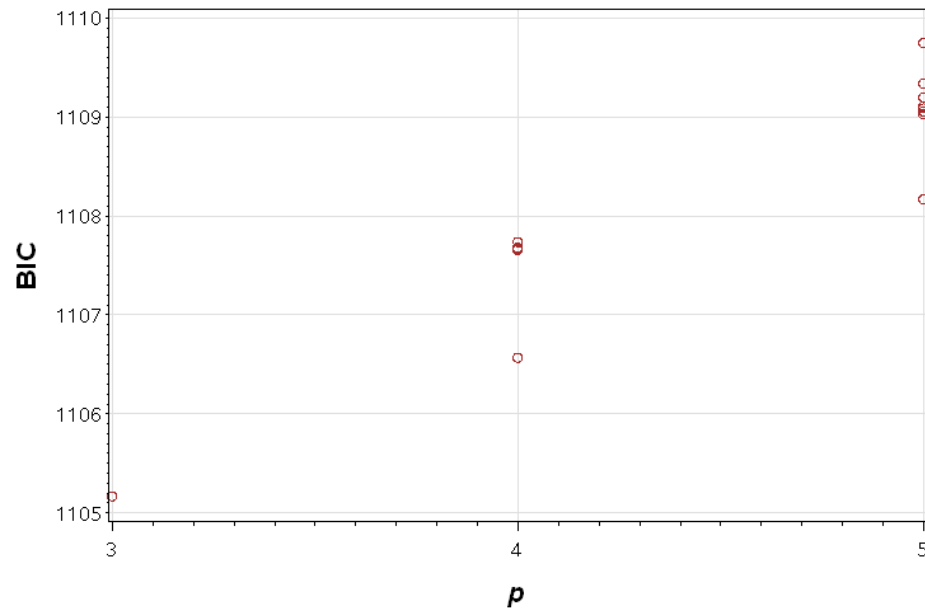
σ_{veh}^2	0.4720
σ_{ε}^2	0.1836

G.4.2 Model Fitting with respect to the 16-term extended Model.

Extended Model (16-terms): Bayesian Information Criterion (BIC) vs. number of terms in model (p) for all possible models respecting hierarchy.



Extended Model (16-terms): Bayesian Information Criterion (BIC) vs. number of terms in model (p) for subset of models respecting hierarchy (CLOSEUP of previous figure).



NO_x (Bag 2): Number of terms (*p*), Goodness-of-fit (BIC) and terms included in the 35 best-fitting candidate models (out of a total of 2,964 possible models with hierarchy). (Terms included in models ranked 1-8 comprise the “superset” for final model-fitting).

Rank	p	BIC	Design Terms											Extended Terms				
			εOH	Arom	RVP	T50	T90	εOH x εOH	T50 x T50	εOH x Arom	εOH x RVP	εOH x T50	εOH x T90	Arom x RVP	Arom x T50	Arom x T90	T50 x T90	RVP x T90
1	3	1105.17	•	•														
2	4	1106.57	•	•	•													
3	4	1107.66	•	•		•												
4	4	1107.67	•	•				•										
5	4	1107.68	•	•						•								
6	4	1107.74	•	•			•											
7	5	1108.17	•	•	•						•							
8	5	1109.03	•	•	•		•											
9	5	1109.06	•	•	•			•										
10	5	1109.09	•	•	•									•				
11	5	1109.11	•	•	•					•								
12	5	1109.2	•	•	•	•												
13	5	1109.34	•	•		•									•			
14	5	1109.75	•	•			•									•		
15	5	1110.2	•	•		•		•										
16	5	1110.2	•	•		•				•								
17	5	1110.21	•	•				•		•								
18	5	1110.21	•	•		•						•						
19	5	1110.23	•	•		•	•											
20	5	1110.25	•	•			•	•										
21	5	1110.26	•	•			•			•								
22	5	1110.29	•	•		•				•								
23	5	1110.33	•	•			•								•			
24	6	1110.61	•	•	•						•			•				
25	6	1110.66	•	•	•		•										•	
26	6	1110.68	•	•	•					•	•							
27	6	1110.69	•	•	•		•				•							
28	6	1110.71	•	•	•			•			•							
29	6	1110.75	•	•		•				•					•			
30	6	1110.81	•	•	•	•					•							
31	6	1111.3	•	•	•		•									•		
32	6	1111.42	•	•	•	•									•			
33	2	1111.53	•															
34	6	1111.53	•	•	•		•	•										
35	6	1111.58	•	•	•		•						•					

NOTE: the model-fitting process for the extended model gives identical results to those from the design model, as presented above.