

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 I.4o

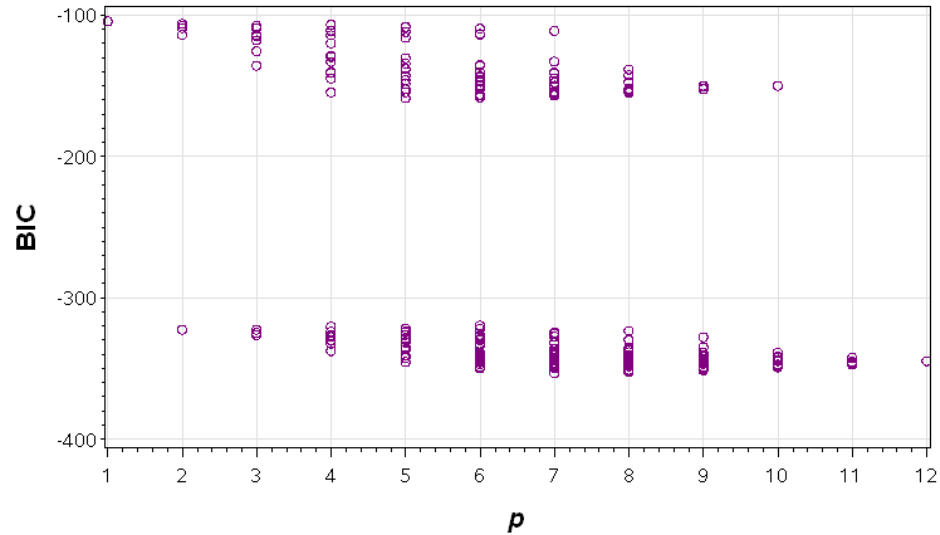
Final Model Fitting

Methane (CH₄) (Bag 3)

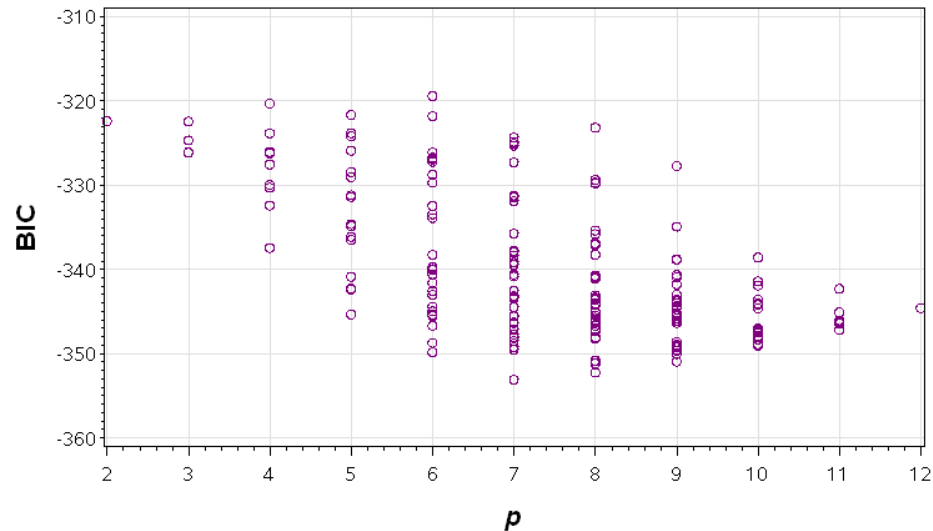
No. Observations:	893	
No. Vehicles:	14	(drop Corolla)
No. censored measurements:	0	
No. missing measurements:	0	
No. measurements removed:	0	
Model Type:	Mixed model	

I.4o.1 Model fitting with respect to the 11-term design model.

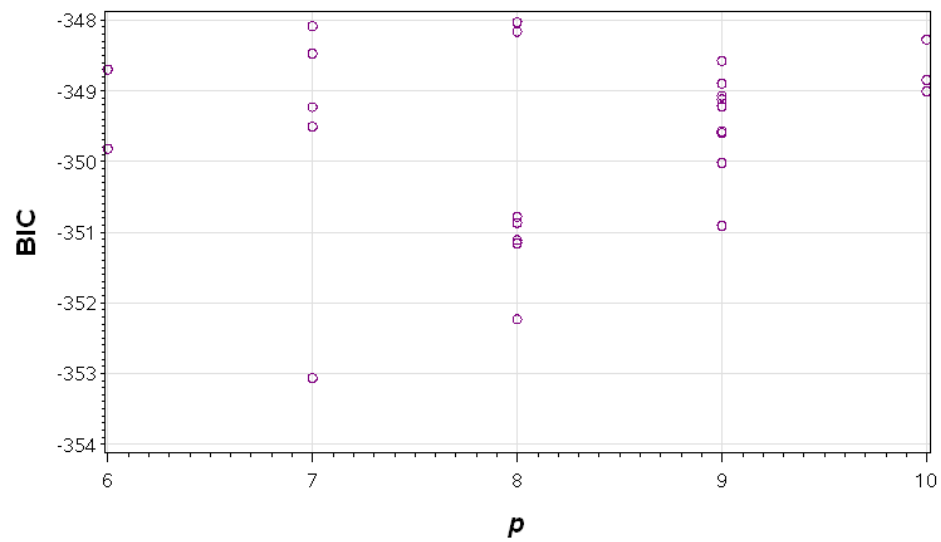
Design Model (11-terms): Bayesian Information Criterion (BIC) vs. number of terms in model (p) for all possible models respecting hierarchy.



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).



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).



CH₄ (Bag 3): 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 1-7 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	etOH x T90
1	7	-353.062	•	•		•	•			•		•	
2	8	-352.229	•	•		•	•		•	•		•	
3	8	-351.155	•	•	•	•	•			•		•	
4	8	-351.109	•	•		•	•	•		•		•	
5	9	-350.906	•	•	•	•	•		•	•		•	
6	8	-350.865	•	•		•	•			•		•	•
7	8	-350.778	•	•		•	•	•	•	•			
8	9	-350.017	•	•		•	•		•	•		•	•
9	6	-349.815	•	•		•	•					•	
10	9	-349.594	•	•		•	•	•	•	•		•	
11	9	-349.567	•	•	•	•	•	•		•		•	
12	7	-349.505	•	•		•	•		•	•			
13	7	-349.226	•	•		•	•		•			•	
14	9	-349.218	•	•	•	•	•	•	•	•			
15	9	-349.116	•	•	•	•	•			•	•	•	
16	9	-349.068	•	•	•	•	•			•		•	•
17	10	-349.003	•	•	•	•	•		•	•	•	•	
18	9	-348.894	•	•		•	•	•		•		•	•
19	10	-348.842	•	•	•	•	•		•	•		•	•
20	6	-348.693	•	•		•				•		•	
21	9	-348.572	•	•		•	•	•	•	•			•
22	7	-348.469	•	•		•	•	•				•	
23	10	-348.27	•	•	•	•	•	•	•	•		•	
24	8	-348.16	•	•	•	•	•		•	•			
25	7	-348.083	•	•		•			•	•		•	
26	8	-348.027	•	•	•	•	•		•			•	
27	7	-347.969	•	•	•	•	•					•	
28	10	-347.863	•	•	•	•	•	•		•	•	•	
29	7	-347.691	•	•		•	•					•	•
30	10	-347.481	•	•	•	•	•	•		•		•	•
31	10	-347.384	•	•		•	•	•	•	•		•	•
32	8	-347.236	•	•		•	•		•	•			•
33	10	-347.21	•	•	•	•	•			•	•	•	•
34	11	-347.144	•	•	•	•	•		•	•	•	•	•
35	10	-347.142	•	•	•	•	•	•	•	•			•

Models fit for CH₄ (Bag 3): (all models include an intercept term).

Model Term	Notation	Model			
		Superset	SM2 ¹	SM3	SM4
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 Represents “Superset minus 1,” etc.

CH₄ (Bag 3): Model fitting history, starting with the 10-term superset model.

Fit Parameters				<i>Test with respect to Previous Model</i>		
Model	p	-2lnL	BIC ¹	Dev.	d	$\text{Pr} > \chi^2$
Superset	11	-380.510	-346.200			
SM2 ²	9	-379.936	-350.907	0.576	2	0.750
SM3	8	-378.619	-352.229	1.317	1	0.251
SM4 ²	7	-376.814	-353.062	1.805	1	0.179

¹ A lower value indicates a better fit.

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

CH₄ (Bag 3): 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	-4.4735	0.1789	14	-25.0	0.000000
Z_e	0.02354	0.009267	871	2.54	0.011
Z_a	-0.09565	0.006507	871	-14.7	0.000000
Z_r	-0.008909	0.007373	871	-1.21	0.23
Z_5	0.02400	0.009333	871	2.57	0.010
Z_9	0.01811	0.006477	871	2.80	0.0053
ZZ_{ee}	-0.000506	0.01230	871	-0.0411	0.97
ZZ_{55}	0.01093	0.009364	871	1.17	0.24
ZZ_{ea}	0.01463	0.006349	871	2.30	0.021
ZZ_{er}	---	---	---	---	---
ZZ_{e5}	-0.01724	0.01321	871	-1.30	0.19
ZZ_{e9}	0.004783	0.006314	871	0.758	0.45

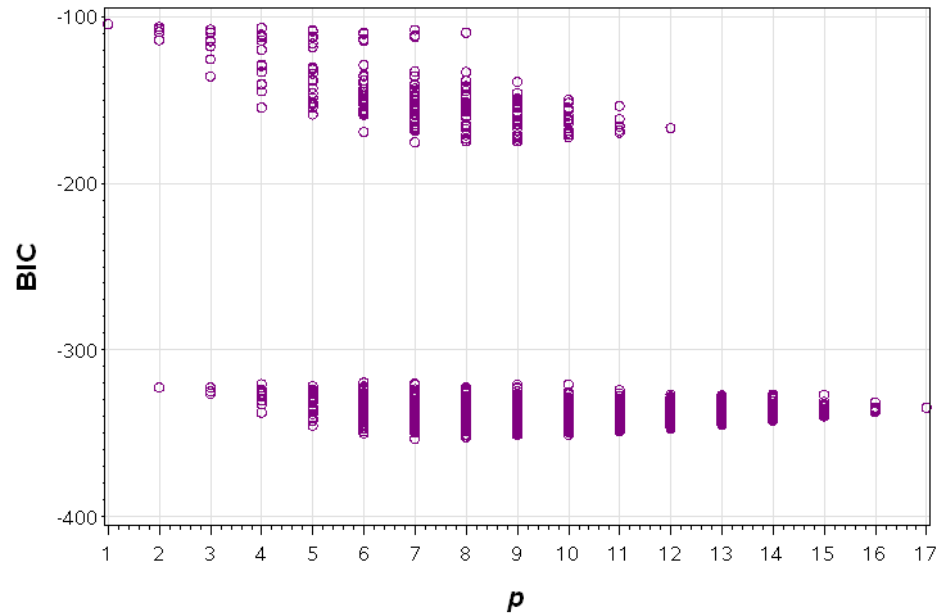
σ_{veh}^2	0.4478
σ_{ε}^2	0.03425

<i>Reduced Model (SM4)</i>				
Estimate	Std. Err.	d.f.	<i>t</i> -value	Pr> <i>t</i>
-4.4742	0.1789	14	-25.0	0.000000
0.02805	0.007619	871	3.68	0.00025
-0.09578	0.006502	871	-14.7	0.00000
0.03025	0.007967	871	3.80	0.00016
0.01691	0.006375	871	2.65	0.0081
0.01528	0.006289	871	2.43	0.015
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-0.02079	0.006491	871	-3.20	0.0014

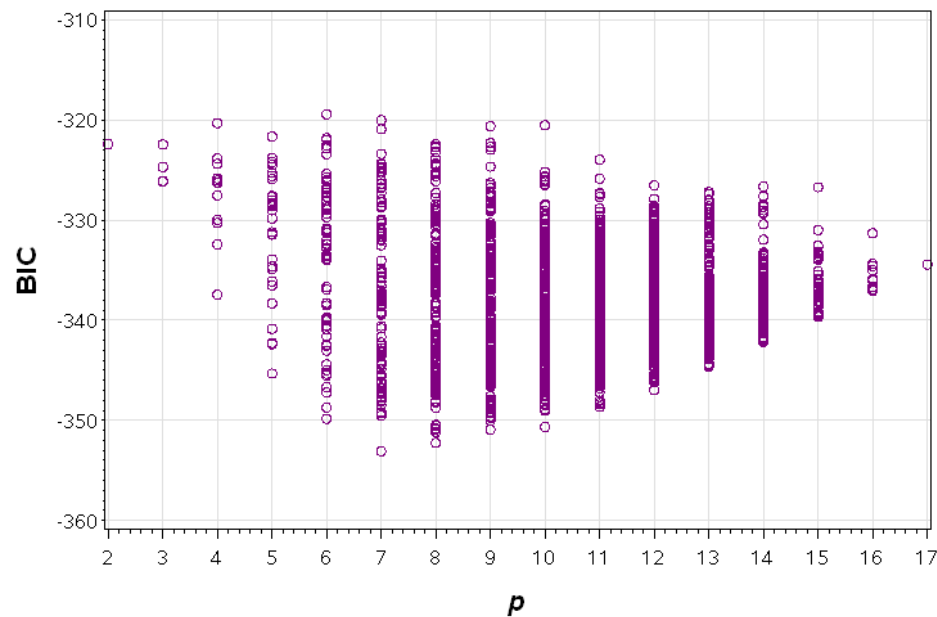
σ_{veh}^2	0.4477
σ_{ε}^2	0.03439

I.4o.2 Model Fitting with respect to the 16-term extended Model.

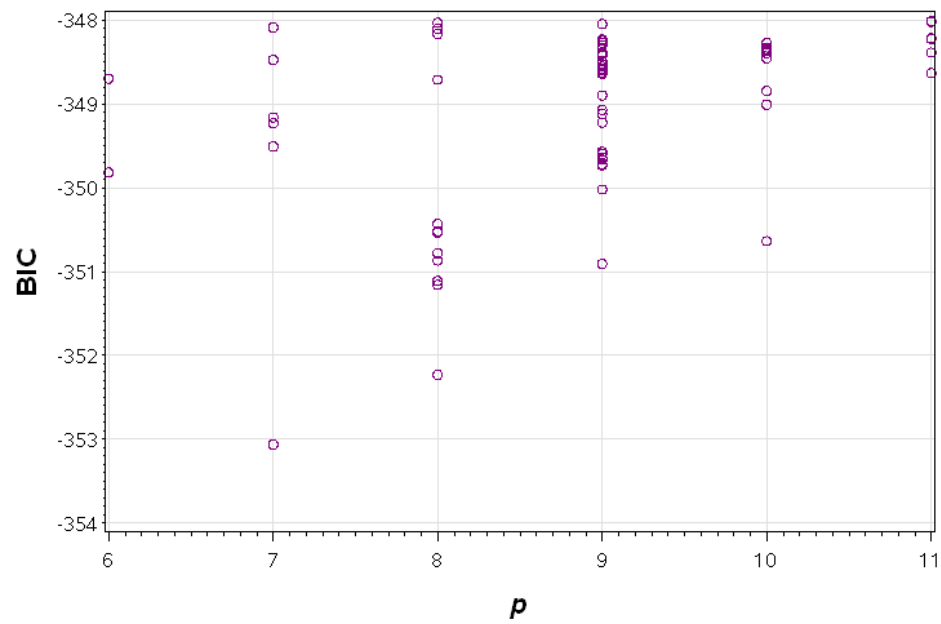
Extended Model (16-terms): Bayesian Information Criterion (BIC) vs. number of terms in model (p) for all possible models respecting hierarchy.



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).



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).



CH₄ (Bag 3): 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 1-5 comprise the “superset” for final model-fitting).

Rank	<i>p</i>	BIC	Design Terms										Extended Terms				
			εOH	Arom	RVP	T50	T90	εOH × εOH	T50 × T50	εOH × Arom	εOH × RVP	εOH × T50	εOH × T90	Arom × RVP	Arom × T50	Arom × T90	T50 × T90
1	7	-353.062	•	•		•	•			•		•					
2	8	-352.229	•	•		•	•		•	•		•					
3	8	-351.155	•	•	•	•	•			•		•					
4	8	-351.109	•	•		•	•	•		•		•					
5	9	-350.906	•	•	•	•	•		•	•		•					
6	8	-350.865	•	•		•	•			•		•					
7	8	-350.778	•	•		•	•	•	•	•							
8	10	-350.633	•	•	•	•	•		•	•		•		•			
9	8	-350.531	•	•		•	•			•		•				•	
10	8	-350.516	•	•		•	•			•		•			•		
11	8	-350.429	•	•		•	•			•		•			•		
12	9	-350.017	•	•		•	•		•	•		•			•		
13	6	-349.815	•	•		•	•					•					
14	9	-349.727	•	•		•	•		•	•		•				•	
15	9	-349.715	•	•	•	•	•			•		•		•			
16	9	-349.66	•	•		•	•		•	•		•			•		
17	9	-349.639	•	•		•	•		•	•		•				•	
18	9	-349.594	•	•		•	•	•	•	•		•					
19	9	-349.567	•	•	•	•	•	•		•		•					
20	7	-349.505	•	•		•	•		•	•							
21	7	-349.226	•	•		•	•		•			•					
22	9	-349.218	•	•	•	•	•	•	•	•							
23	7	-349.155	•	•		•	•					•			•		
24	9	-349.116	•	•	•	•	•			•	•	•					
25	9	-349.068	•	•	•	•	•			•		•			•		
26	10	-349.003	•	•	•	•	•		•	•	•	•					
27	9	-348.894	•	•		•	•	•		•		•			•		
28	10	-348.842	•	•	•	•	•		•	•		•			•		
29	8	-348.707	•	•	•	•	•					•			•		
30	6	-348.693	•	•		•				•		•					
31	9	-348.636	•	•	•	•	•			•		•			•		
32	11	-348.629	•	•	•	•	•		•	•		•		•	•		
33	9	-348.62	•	•	•	•	•			•		•				•	
34	9	-348.594	•	•	•	•	•			•		•				•	
35	9	-348.574	•	•	•	•	•			•		•					•

NOTE: Model fitting with respect to the 16-term extended model gives identical results to those obtained for the 11-term design model, as presented above.