Supporting Information

How Well Do We Know the Future of CO_2 Emissions? Projecting Fleet Emissions from Light Duty Vehicle Technology Drivers

Niall P D Martin[1], Justin D K Bishop[1], and Adam M Boies[1;2*]

[1]Energy Efficient Cities Initiative, University of Cambridge Department of Engineering, Trumpington Street, Cambridge CB2 1PZ, United Kingdom
[2]Department of Civil, Environmental or Geo-Engineering, University of Minnesota, Minneapolis, MN 55455-0116, USA

[*]Corresponding author (a.boies@eng.cam.ac.uk, +44 1223 746 972)

Appendix A

EV and PHEV sales were first compared from 2001-2013, where the adoption of the former system was shown to have occurred at a faster rate. This result was established after the logistic sales function of Equation 1 was fit to historical UK vehicle registration data in Appendix A.1, from which EV and PHEV sales were correspondingly estimated to have increased by 216% and 201% per annum since 2001, respectively. Whilst statistically-significant regressions were derived for both technologies, discontinuities in vehicle sales functions were also noted that were attributed to the economic recession between 2008-2010.

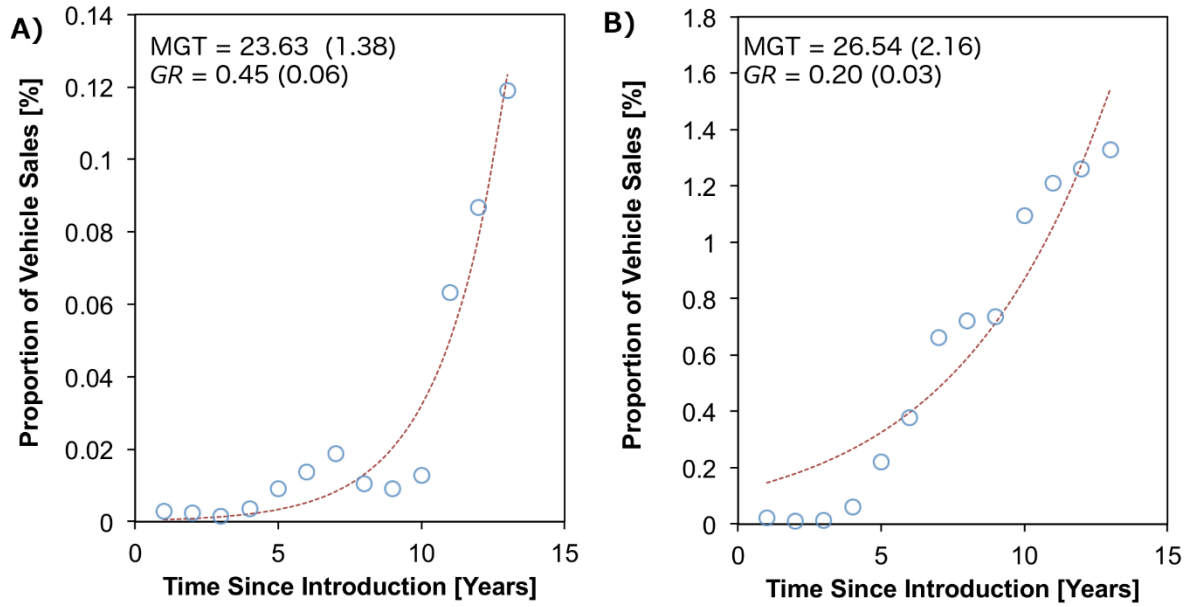

Figure S1: Least-squares logistic regression functions (broken line) for EV's (A) and PHEV's (B) based on sales data (blue circles) from 2001-2013. Standard errors for *MGT* and *GR* parameters shown in brackets.

Appendix B

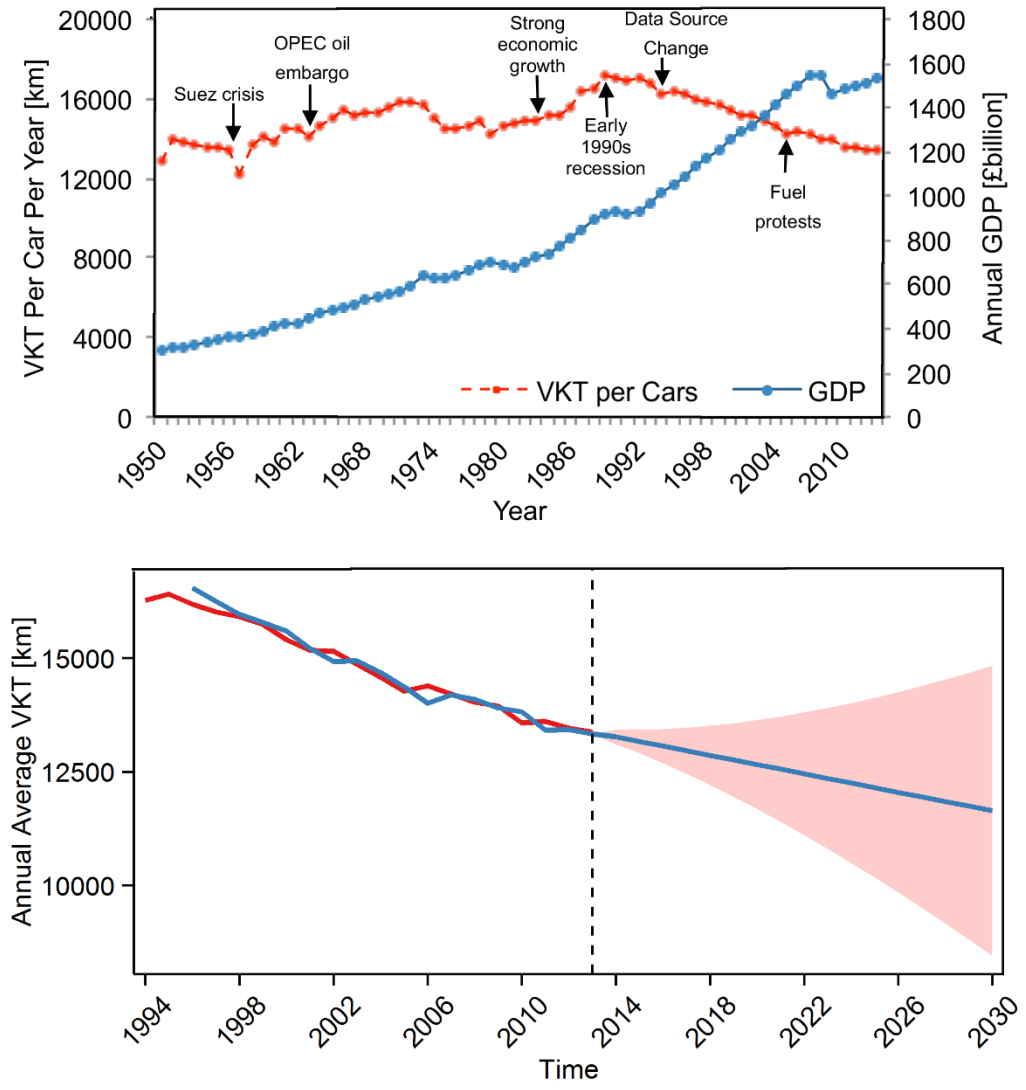

Figure S2: Average UK passenger vehicle activity, measured for historic (top) and future (bottom) VKT. Holt Forecasts are used to project annual average VKT, with 95% prediction interval about the mean. Red are blue regression lines represented the known data and Holt models, respectively. VKT increased by 12% between 1985 and 1990, when GDP was 1.3% above the historic national average of 2.6%. Similarly, VKT declined by 4.4% between the 1990 to 1994 recession when the annual average GDP growth was 0.6%[1].

Appendix C

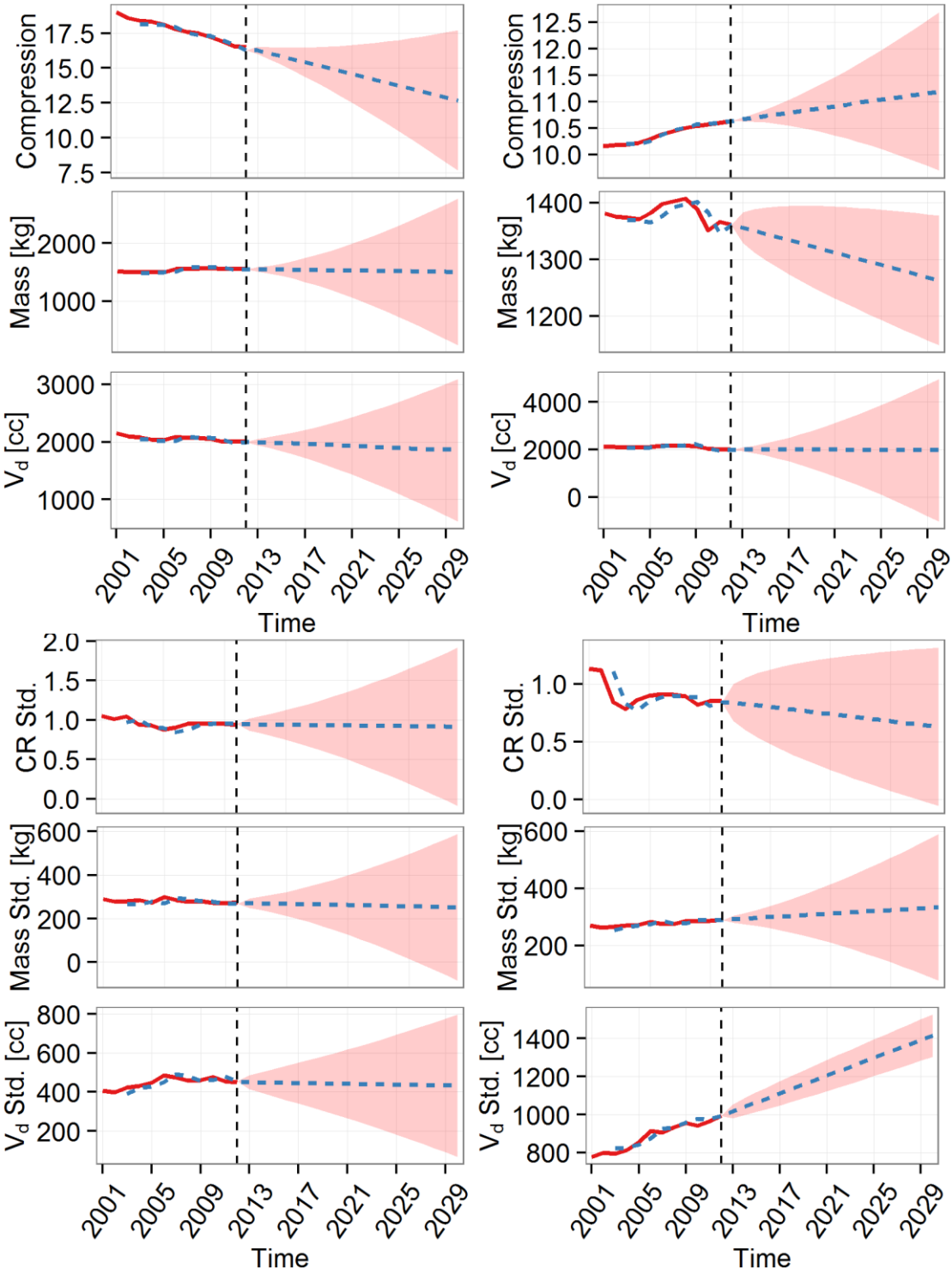

Figure S3: Holt exponential smoothing projections (blue dashed line) for the mean (top) and standard deviation (bottom) of CI (left) and SI (right) mass, engine size and compression ratio, with a 90% prediction interval about the mean (red shading).

Appendix D

Table S1: STEM sales projection by propulsion system in 2030.

Scenarios	Mean SI (StDev.) [%]	Mean CI (StDev.) [%]	Mean EV (StDev.) [%]	Mean PHEV (StDev.) [%]
Baseline	22.76	61.84	3.39	12.00
	0.47	1.27	0.16	1.73
High CI	22.76	61.84	3.39	12.01
	0.47	1.28	0.16	1.74
High EV	16.27	44.22	11.89	27.61
	1.08	2.94	0.55	3.99
High CI & EV	16.27	44.22	11.89	27.62
	1.09	2.96	0.54	4.00

Table S2: STEM stock projection by propulsion system in 2030.

Scenarios	Mean SI (StDev.) [%]	Mean CI (StDev.) [%]	Mean EV (StDev.) [%]	Mean PHEV (StDev.) [%]
Baseline	31.66	60.64	1.59	6.11
	0.13	0.31	0.10	0.42
High CI	28.81	63.48	1.59	6.11
	0.12	0.31	0.10	0.42
High EV	28.21	52.22	5.57	13.99
	0.30	0.72	0.34	0.97
High CI & EV	25.56	54.88	5.57	13.99
	0.28	0.74	0.34	0.97

Appendix E

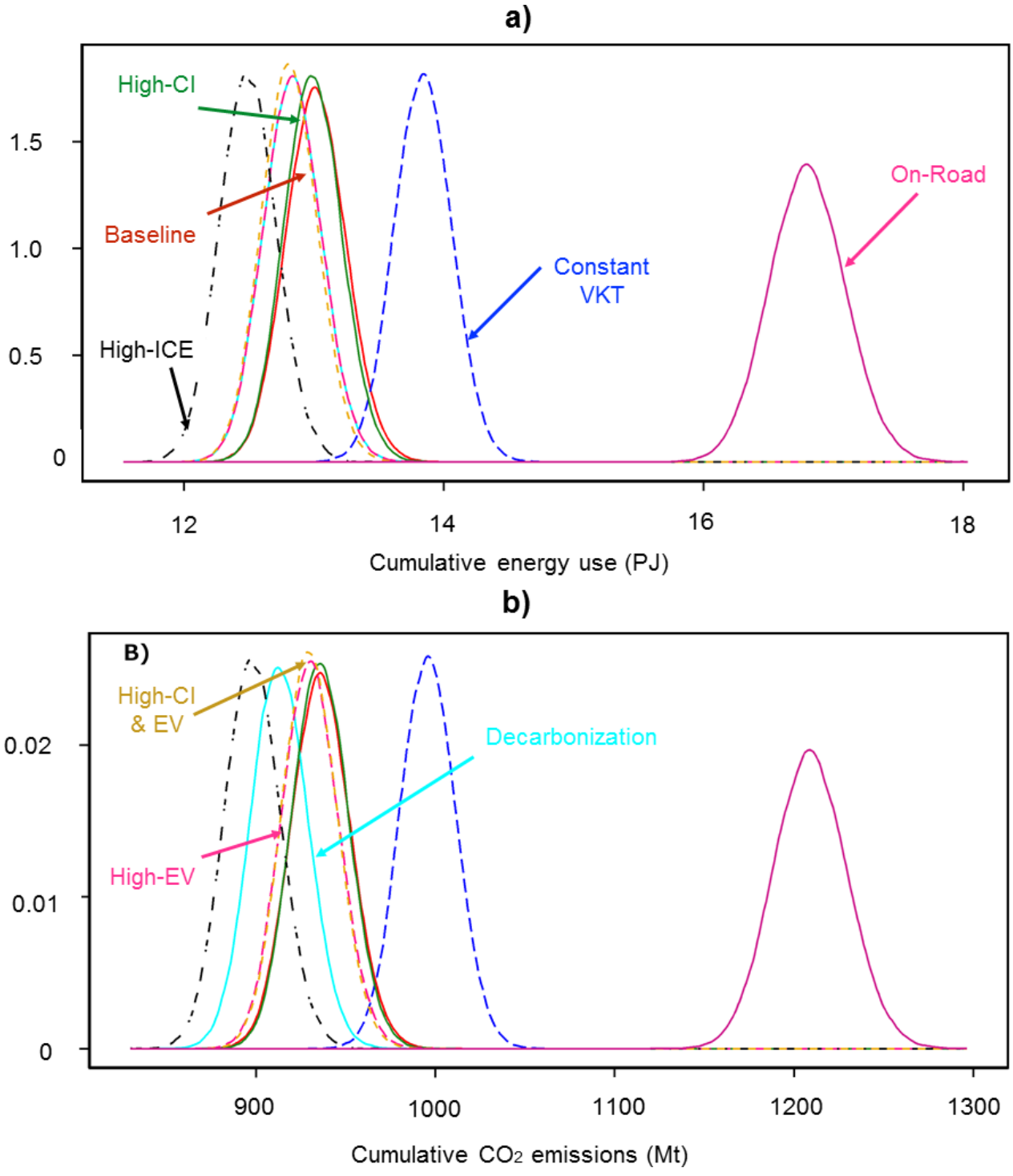

Figure S4: Comparison between cumulative (A) energy-use and (B) emissions over all propulsion systems, by scenario. Results calculated by summing over all propulsion systems by model and calendar year.

Appendix F

Sales-weighted versus average fuel consumption

The relationship between the fuel consumption of available vehicles and sales-weighted fuel consumption shown in Figure F3, where the linear trend from 1997 to 2011 indicates a consistency in consumer preference. Consumers selected more efficient vehicles than the available average as the mean sales-weighted fuel consumption was 4% and 7% lower for SI and CI vehicles than the mean of available vehicle fuel consumption. Clustering of CI data around 6.2 L/100 km denotes the only exception to this trend. CI vehicle manufacturers increasingly prioritised adherence to Euro 4 and 5 air-quality emissions standards during this period (2002-2008), at the expense of fuel efficiency improvements[54]. This resulted in the sales-weighted fuel consumption of CI vehicles decreasing by just 0.21 L/100 km between 2002-2008, compared to 0.92 L/100 km for SI. Cumulative reductions in fuel consumption between 1997-2011 were similar for both technologies, in spite of the CI stagnation period, as SI and CI sales-weighted values decreased by 27% and 26% respectively[3] and the average available fuel consumption decreased by 22% (SI) and 19% (CI)[6]

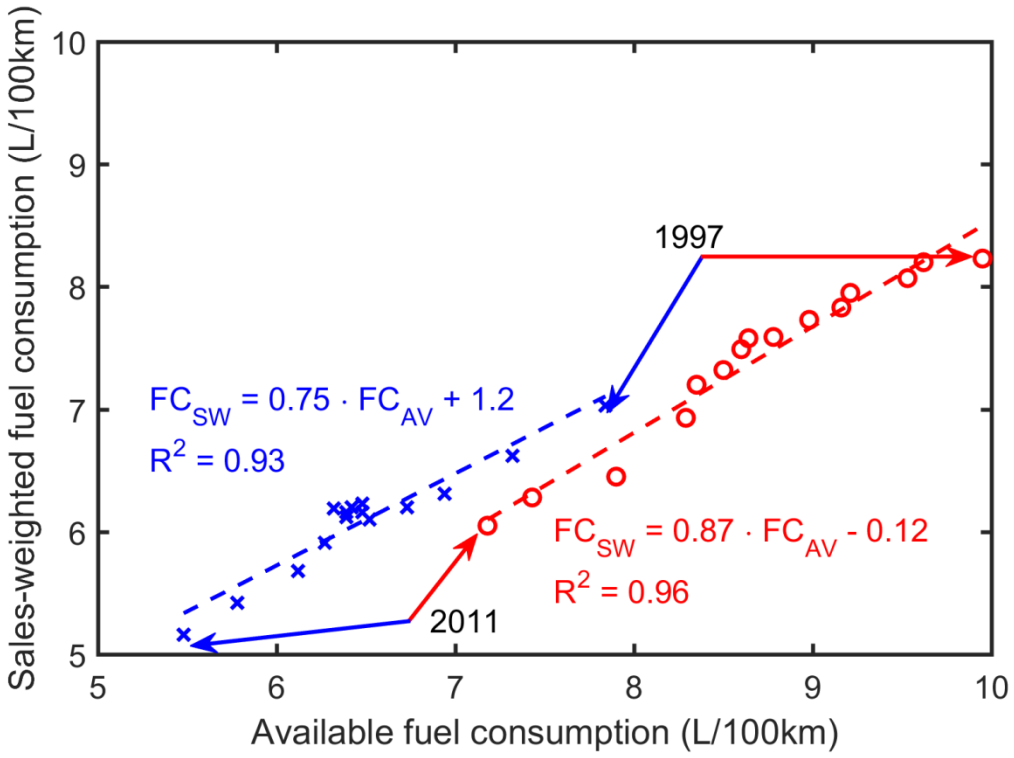

Figure S5: Regression for sales weighted NEDC fuel consumption (FC_{SW}) against available vehicle NEDC fuel consumption (FC_{AV}) from 1997 (top right in each regression) to 2011 (bottom left in each regression) for SI (red) and CI (blue) vehicles[2,3]. The slope represents the rate of change between both estimates.

References

(1) ONS, Gross Domestic Product (GDP). *Office for National Statistics*, **2016**.
(2) DfT. Vehicle licensing statistics: 2015. *Department for Transport*, **2016**
(3) CAP. CAP Vehicle Data. *CAP*, **2015**