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Estimating direct rebound effects for personal automotive travel in Great Britain

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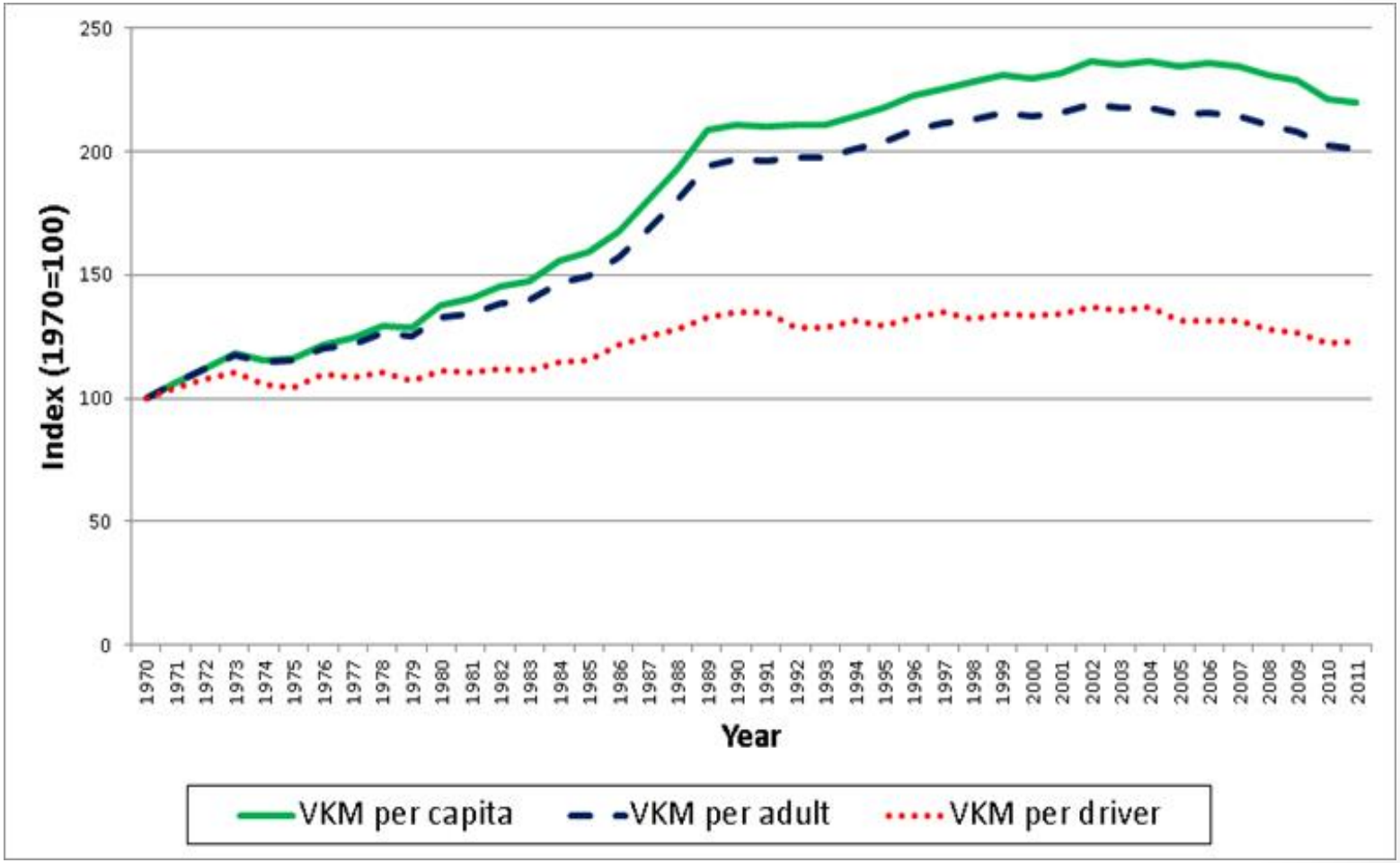
Headline Summary

- Using on-road fuel intensity, we are unable to obtain a statistically significant estimate of the direct rebound effect
- But using both fuel prices and fuel costs per kilometre, we obtain a number of statistically significant estimates that suggest a direct rebound effect of around 18%
- We find no evidence of a relationship between the statistical robustness of our models and the estimated size of the direct rebound effect

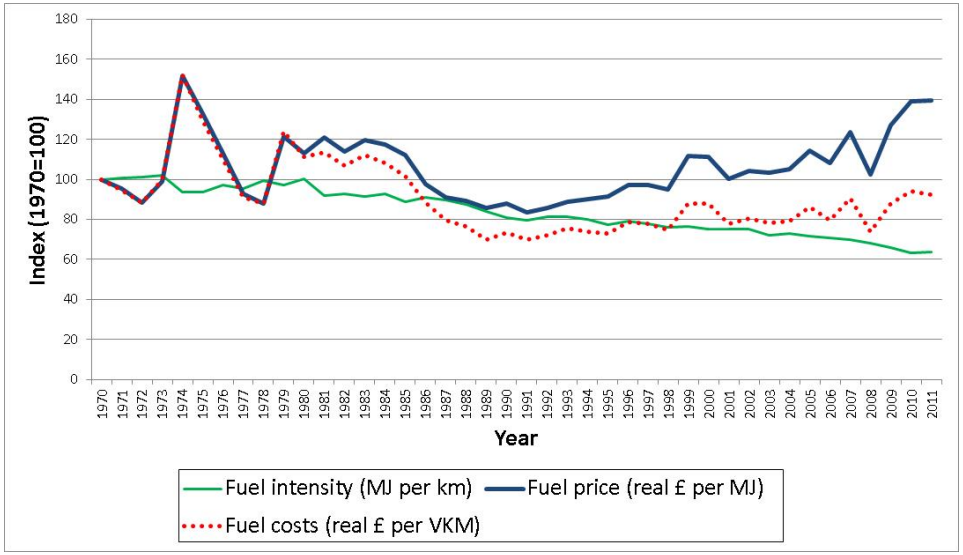
Context

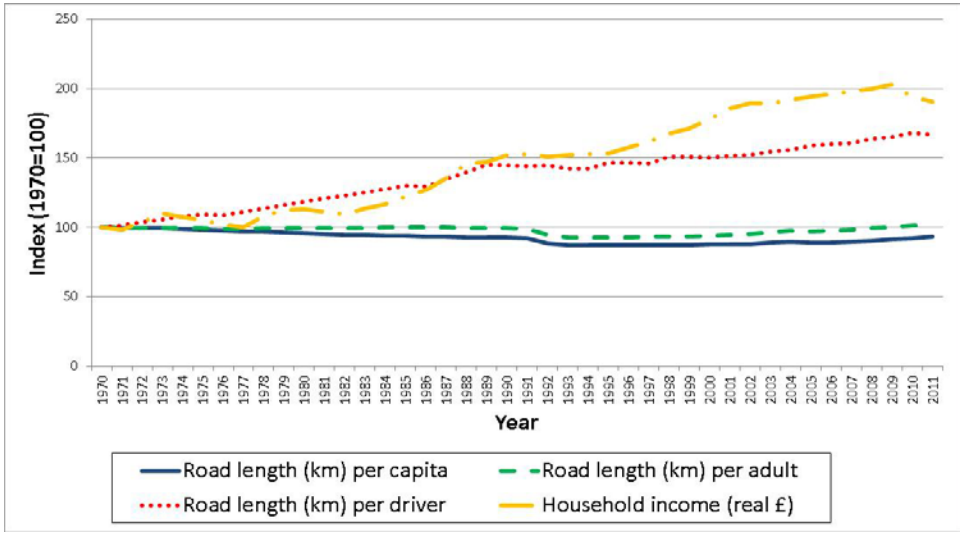
- Technical improvements **lower** transport **costs** and thereby encourage **increased** transport activity and **energy** use
- Passengers travel further and more often in larger, faster, more powerful and emptier cars
- But establishing causality is difficult when (i) data are limited and uncertain (ii) data exhibit limited change over time (near horizontal lines in geometric terms); (iii) appropriate regression methods are complicated to implement

Methods – data I



Methods – data II





Methods – modelling rebound

- Approach one: **how does improved technical efficiency** (*declining* vehicle fuel intensity and *declining* fuel prices) ***increase*** **travel** (vehicle kilometres travelled)?

- Approach two: **how does improved technical efficiency** (*declining* fuel costs per kilometre) ***increase*** **travel** (vehicle kilometres travelled)?

Methods – model groups

Group	Explained variable (S)	Normalisation of explained variable	Rebound specification
1	VKM	Per capita	Fuel price (£/MJ) and intensity (MJ/km)
2	VKM	Per adult	Fuel price (£/MJ) and intensity (MJ/km)
3	VKM	Per driver	Fuel price (£/MJ) and intensity (MJ/km)
4	VKM	Per capita	Fuel cost of driving (£/km)
5	VKM	Per adult	Fuel cost of driving (£/km)
6	VKM	Per driver	Fuel cost of driving (£/km)

Methods – model types

- Static regression models: quantify the change in car travel over time attributable to different variables (rebound variables, income, urbanisation and congestion and oil price shocks)
- Dynamic regression models: acknowledge that car travel in any particular year is partly dependent on car travel in previous years
- Co-integrating regression models: in effect, these are similar to static regression models but (may be) optimal for 'trending' variables

Methods – diagnostics (static and dynamic models)

- **Coefficients:** do they behave? [3 tests]
- **Residuals:** do they behave? [3 tests]
- **Stability:** are predictions stable? [2 tests]
- **Parsimony**: is their a sound balance between good predictions and model complexity? [3 tests]
- **Functional form:** is the model structure appropriate? [2 tests]

48 MODELS x 13 DIAGNOSTIC TESTS = 624 TESTS ON STATIC AND DYNAMIC MODELS

Methods – diagnostics (co-integrating models)

- **Coefficients:** do they behave? [3 tests]
- **Residuals:** do they behave? [1 test]
- **Stability:** are predictions stable? [1 test]
- **Goodness of fit**: how well does the model match the data? [1 test]

6 MODELS x 6 DIAGNOSTIC TESTS = 36 TESTS ON CO-INTEGRATING MODELS

Methods - robustness

Methods – robustness composites I

GLOSSARY OF STATISTICAL TERMS

STATISTICS PORTAL

COMPOSITE INDICATOR

Definition:

A composite indicator is formed when individual indicators are compiled into a single index, on the basis of an underlying model of the multi-dimensional concept that is being measured.

Robustness (health / strength) ←

Methods – robustness composites II

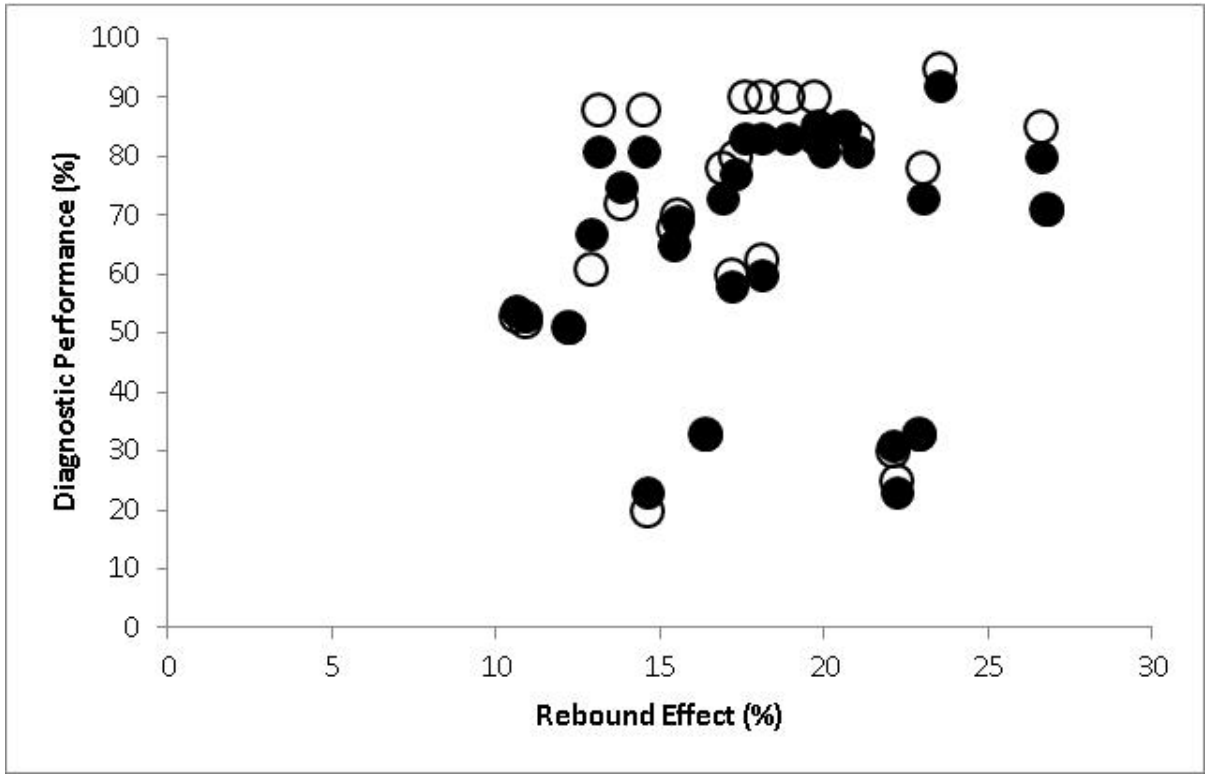
Coefficients			Residuals			Stability		Parsimony			Functional Form	
A Measure	B Measure	C Measure	A Measure	B Measure	C Measure	A Measure	B Measure	A Measure	B Measure	C Measure	A Measure	B Measure
2 points	2 points	1 point	2 points	1 point	1 point	2 points	2 points	1 Point	1 point	1 point	2 points	2 points

Static and dynamic models

Co-integrating models

Coefficients			Residuals	Stability	GOF
A Measure	B Measure	C Measure	A Measure	A Measure	A Measure
2 points	2 points	1 point	1 point	2 points	2 points

Results – rebound (long run)



n = 28

o= complex robustness

●= simple robustness

Conclusions

- If changes in fuel efficiency are taken as the appropriate explanatory variable, we find **no** evidence of a long-run direct rebound effect in GB over the last 40 years.

- If changes in either the fuel cost of driving or fuel prices are taken as the appropriate explanatory variable we find **good** evidence of a direct rebound effect, with most estimates lying in the range **10%** to **27%** with a mean of **18%.**

- The estimated size of the rebound effect does not depend on model quality.

- However, the aggregate rebound effect (including direct, indirect and economy wide components) is more important yet extremely difficult to quantify → unacceptable levels of uncertainty.

Thanks!

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