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Beyond 'Dieselgate': Implications of unaccounted and future air pollutant emissions and energy use for cars in the United Kingdom

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HIGHLIGHTS

- Explores the recent 'Dieselgate' affair and potential policy responses.
- Impacts on human health of 'real world' NOX emissions in the UK are significant.
- De-dieselization can have air quality benefits while showing few carbon disbenefits.
- Electrification shows largest 'co-benefits' but needs transformative approach.
- Electrification may mean faster decline in road tax revenues.

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ABSTRACT

The 'Dieselgate' emissions scandal has highlighted long standing concerns that the performance gap between 'real world' and'official' energy use and pollutant emissions of cars is increasing to a level that renders 'official' certification ratings virtually ineffective while misleading consumers and damaging human health of the wider population. This paper aims to explore the scale and timing of historic and future impacts on energy use and emissions of the UK car market. To achieve this aim it applies a bespoke disaggregated model of the transport-energy-environment system to explore the impacts of retrospective and future policy scenarios on the UK car market, trade-offs between greenhouse gas and air quality emissions, and fuel use and associated tax revenues. The results suggest that the impacts on human health of 'real world' excess NO_X emissions in the UK are significant. Future 'low diesel' policies can have significant air quality benefits while showing few (if any) carbon disbenefits, suggesting future car pricing incentives may need to be rebalanced taking more account of effects of local air pollution. Car pricing incentives are however unlikely to transform the car market without additional market changes, industry push, infrastructure investment and policy pull aimed at cleaner, lower carbon vehicles.

1. Introduction

1.1. The challenge – and potential opportunity?

The 'Dieselgate'[1] emissions scandal has highlighted growing concerns that the performance gap between 'real world' and 'official' energy use and air pollutant emissions of road vehicles is increasing to a level that renders 'official' certification ratings virtually ineffective while misleading consumers and damaging human health of the wider population. While real world CO_2 emissions have been shown to be on average a third higher (CCC, 2015b; ICCT, 2014a; TandE, 2015a), NO_X emissions can be up to 40 times higher than official certification values and standards operating in the EU (Hagman et al., 2015; ICCT, 2014b; Weiss et al., 2012), the US (Barrett et al., 2015) and China (Lau et al., 2015; Shen et al., 2015). For CO_2, the gap between test results and real-world

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[1] While there is no official definition of the term 'Dieselgate', it has become synonymous with the use by the Volkswagen Group of a 'defeat device' that detects when a diesel car is undergoing an official emissions tests and optimises engine performance to minimise air pollutant emissions to meet stringent emissions regulations. The device is only activated during the official test. Vehicles by other manufacturers have also been shown to exceed emissions in real world driving conditions; however, there has been no evidence of 'defeat devices' being used outside Volkswagen.

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performance has increased from 8% in 2001–31% in 2012 and 40% in 2014 (TandE, 2015a). Up to nine out of ten diesel cars on Europe's roads are said to break European NO_X pollution limits,[2] and the current generation of Euro 6 vehicles have been shown to emit, on average, seven times more NO_X than certified European values (Beevers et al., 2012; Dehmer, 2015; ICCT, 2014b). While the emissions scandal began in the US, little quantified evidence exists on the effects of excess emissions in the UK, which is a larger market for diesel cars. There is also a lack of quantification of the potential trade-offs between human health and climate change mitigation effects in the UK.

Given that transport accounts for 46 per cent of all NOx emissions in the region (EEA, 2015), the performance gap partly explains why NOx emissions in many European countries continue to miss targets (Beevers et al., 2012). The other reasons are the growth in overall traffic and the increase in the diesel market share for cars. In the UK, for instance, diesel vehicles accounted for fewer than 1 per cent of cars on the road in 1984 – last year that figure had risen to more than a third, with new registrations totalling about 1.35 million (or half) of all new cars in 2014 (SMMT, 2014). This compares to the almost 1.2 million VW diesel vehicles affected in the UK, and about 11 million VW diesel vehicles worldwide (Sheffield, 2015; Yeomans, 2015).

1.2. Lack of effective policy response in the UK

The human health 'costs' of diesel related air pollution (see Supplementary material S1 for further details) are highly policy-relevant. The UK Government has been subject to legal proceedings for failing to meet European Limit Values for NO_2, and their plans to reduce NO_2 concentrations and meet these limits was submitted to the European Commission at the end of 2015 (DEFRA, 2015a). Some major urban hotspots will continue to exceed EC limits for another decade to come (DEFRA, 2015a) as effective mitigation of local air pollution is proving to be an enormous challenge in cities across the globe (Barrett et al., 2015; Carrington, 2016; Walton et al., 2015; Woodcock et al., 2009). The policy response so far has been slow and ineffective as the reliance on updating the vehicle type-approval testing procedure and associated legislation are still on-going (CCC, 2015b) and will not have significant effects for another decade or more.

The proposed policy and technological solutions include actions at national and local levels: a national diesel car scrappage scheme; a ban on (older) diesel vehicles in cities; the requirement for new taxis to be ULEV by a certain date; rebalancing of national fuel duty and road tax (Vehicle Excise Duty, or VED) consistent with reducing not just CO_2 emissions but also NO_2 and particulate matter (PM); and national monetary incentives for switching to cleaner vehicles including ultra-low emission cars, taxis, vans and buses (DEFRA, 2015b; UK EAC, 2015). The quantified effects of these measures in the UK are largely unknown.

Partly fuelled by the 'Dieselgate' affair, the electrification of transport has gained further momentum, with Germany announcing it is to provide financial incentives of around €5000 for people to buy electric cars (EurActiv, 2015a, 2015b) and the UK extending its plug-in vehicle grant (£5000 per ULEV) that has led to a 1% take up of plug-in vehicles amongst total new vehicle registrations of 2.6 million in 2015 (SMMT, 2016). Some commentators suggest that continuing reductions in battery prices will bring the total cost of ownership of plug-in vehicles below that for conventional-fuel vehicles by 2025, even with low oil prices (BNEF, 2016). However, doubts remain whether plug-in vehicles are direct replacements of incumbent technologies or perceived as higher risk investments, thus limiting potential take-up (AEA Technology, 2009; BERR and DfT, 2008; Offer et al., 2011).

Some commentators are favouring a diesel scrappage scheme similar to that of 2009/10, with diesel car owners being offered up to £2000 to scrap their car and buy an ultra low emission vehicle (ULEV) instead (Cellan-Jones, 2015; Kollewe, 2015a; Vaughan, 2014). However, such a scheme may come at a cost to the taxpayer in the hundreds of millions (Vaughan, 2014) and may be considered unfair as it constitutes a direct subsidy to existing car owners. Moreover, as diesel vehicles emit 15–20% less CO_2 than a petrol equivalent, they have also made a significant contribution to climate change mitigation – an argument that was explored in this paper by investigating the trade-offs between meeting air quality and climate change objectives (Kollewe, 2015b; van der Zwaan et al., 2013; Vaughan, 2016).

1.3. Aims and objectives of this paper

This paper addressed the above challenge and potential policy and market solutions in two ways. First, it quantified the human health impacts and associated costs of 'real world' excess NO_X emissions in the UK context and compare this with an alternative pathway simulating a retrospective purchase penalty for diesel cars between 2009 and 2015. Second, it quantified the NO_X-related human health and climate change mitigation impacts of future policy scenarios aimed at the UK diesel car market.[3] This paper thus aims to fill existing gaps in the work going on relating to the assessment of 'real world' vs 'official' emissions and potential policy responses elsewhere which: (a) ignores the potential trade-offs between human health and climate change mitigation impacts; (b) lacks detailed analysis of how policy and market signals can change the evolution of the car market; (c) ignores wider fuel and/or vehicle life cycle emissions impacts in comparing different pathways; and (d) lacks investigating the impacts on transport fuel use and associated tax revenues.

2. Approach, methods and data

2.1. Approach and choice of modelling tool

To achieve the above aims the study applied an existing and previously published transport-energy-environment modelling framework that has been applied in a number of policy modelling studies (Anable et al., 2011; Anable et al., 2012; Brand et al., 2013; Brand et al., 2012). The UK Transport Carbon Model (UKTCM) was the tool of choice for this analysis because it integrates a household car ownership model, vehicle consumer choice model, vehicle stock evolution model and vehicle and fuel life cycle emissions model in a single scenario modelling framework. The integrated transport sector tool is able to provide policy-focused conclusions which allow an assessment of the effectiveness of different policy instruments (including regulation, pricing and availability of charging infrastructure) on different vehicle *and* consumer segments. UKTCM has the ability to place the 'de-dieselization' and electrification of the car market in the context of other (low carbon) transport behaviours on the basis of their whole life cycle emissions and impacts on human health, including potential changes in the way in which cars are used, together with

[2] European emission standards for vehicles http://ec.europa.eu/environment/air/transport/road.htm

[3] This paper focused on NO_X pollution and standards as this was the issue surrounding the Dieselgate affair. It is important to note that the inclusion in the damage cost calculation of other pollutants, notably PM, may change the damage cost values. Since total multi-pollutant valuations were likely to increase the totals, the figures reported in this study can be considered on the conservative side.