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Carbon Policies Targeting Road Transport: Is There a Safety Consequence?

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Abstract

One potential interaction between environmental and safety goals in transport is found within the vehicle fleet where fuel economy and safety impose conflicting requirements on vehicle design. Larger and heavier vehicles have a better secondary safety performance during a crash. On the other hand, they are associated with higher levels of fuel consumption and carbon emissions. This issue has generated debate amongst researchers and policy makers when formulating policies to improve the environmental performance of the road transport system. This research investigates the safety consequences of changes in vehicles mass within the vehicle fleet aimed at increasing fleet fuel economy. The estimated relationships between vehicle design, particularly mass, and each of carbon emissions and safety performance were used to investigate partial safety and environmental effects of changes in mass distribution within the fleet using an incremental approach. Results generally showed that the relationship between carbon emission and safety performance in vehicle design depends on the characteristics of the vehicle fleet, and in particular, mass distribution. It was shown that an informed change in the mass distribution not only imposes no trade-off between the fuel economy and safety goals, but also could lead to a desirable outcome in both aspects.

Keywords: Vehicle mass; secondary safety; driver injury risk; two-car crashes; fuel consumption; carbon emissions

1. Introduction

Environmental and safety goals in transport can interact in several different ways. One of these potential interactions is found within the vehicle fleet where fuel economy and safety impose conflicting requirements on

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vehicle design. Larger and heavier vehicles have a better secondary safety performance in that they give a better protection to their occupants during a crash. On the other hand, they are associated with higher levels of carbon emissions. This issue has often generated debate amongst researchers and policy makers when policies to reduce carbon emissions of the road transport system are to be formulated. One of the main concerns is the consequent effect on traffic fatalities and injuries of a reduction in mass and size of vehicles in an attempt to improve the fuel economy and hence reducing carbon emission of the vehicles.

A thorough review of relevant literature reveals that arguments over the issue of interaction between environmental and safety policies has often been made based on either little research evidence on one or both sides, or evidence based on research that has inadequacies in the applied methodologies (Tolouei, 2011). Findings from some key literatures on this subject are summarized below.

A report by the US National Research Council (NRC, 2002) concluded that changes in masses of cars and light trucks in the US since the 1970s, some of which was due to Corporate Average Fuel Economy (CAFE) standards, could have resulted in 1300 to 2600 additional fatalities in 1993. This conclusion was based on an earlier analysis by Kahane (1997) where he estimated the effect of mass reduction in passenger cars, light trucks and vans on fatalities. Findings from this report were later superseded by applying different analytical techniques to more recent crash data where Kahane (2003) estimated a larger fatality increase as mass is reduced for all crash modes. Crandall and Graham (1989) analyzed US time-series data from 1947-1981 and found that additional fatalities occurred as a result of CAFE standards through estimating an increase in fatalities by a decrease in vehicle mass and by linking higher fuel efficiencies to a decrease in mass of new cars.

The methodology they used is correctly questioned by other studies in terms of the type of data and modelling approach used (Noland, 2004) and the time-series period selected (Ahmad and Greene, 2005). Noland (2004, 2005) used count data methods and accounted for heterogeneity and other contributing factors to analyze the effects of average fuel economy of vehicles on traffic-related fatalities. He examined two different aggregate datasets. Using US state-level time-series data, he found that improvements in fuel efficiency were associated with increased fatalities in the 1970s, but this effect had largely disappeared after the mid 1980s (Noland, 2004). He also analyzed country-level time-series data from 13 countries and found that changes in vehicle efficiency are not associated with changes in traffic fatalities (Noland, 2005). Using co-integration analysis and time-series data on US light duty vehicle fuel economy and highway fatalities, Ahmad and Greene (2005) found the unexpected result that the stationary linear relationship between the average fuel economy of passenger cars and light trucks, and highway fatalities is negative meaning that reduced fuel consumption is linked to fewer fatalities. The inconsistencies in the results of these studies linking average fuel consumption to the number of fatalities are partly due to the different vehicle fleets and different time periods studied. Besides, since the effect of vehicle mass is not controlled for, it is not clear to what extent the changes in average fuel consumption are related to the changes in vehicle mass.

As a result of the knowledge gaps and the uncertainties in the underlying relationships, there are differences and sometimes conflicts amongst the results of the studies that have investigated the issue of potential interaction between carbon emissions and safety performance in vehicle design within the fleet. Such gaps could limit the creditability of research findings on the existence of any trade-off. These gaps are addressed in detail in this paper and a methodology is used to investigate the partial effects of a given change in mass distribution within the fleet on each of fleet fuel economy and crash injuries and fatalities based on the estimated underlying relationships. It should be noted that vehicle fuel consumption rate is used throughout this paper as an indicator of carbon emissions as carbon emission rate is directly related to vehicle fuel consumption rate.

2. Effects of mass on vehicle fuel consumption and safety

2.1. Vehicle Mass and Fuel Consumption

Amongst various design features, vehicle mass is a key variable having the potential to considerably affect carbon emissions and fuel consumption rate. Depending on the engine efficiency of a vehicle and the energy