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Killing kilos in car accidents: Are external costs of car weight internalised? ☆

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ABSTRACT

Vehicle weight imposes external costs on a car accident collision partner. In the EU, the external costs through material damage are internalised through obligatory insurance, but this does not hold for the external costs related to injuries and fatalities. We estimate these external costs for the Netherlands for two-vehicle crashes. We find that a 500 kg increase in the weight of the other car increases the probability of a fatality by about 70% over the mean fatality rate, in the same order, but somewhat higher than reported for US. For serious injuries, this effect is about 30%, very close to the results for US. However, because the mean fatality/serious injury rate due to two-vehicle crashes is low in the Netherlands, the annual marginal external costs of car weight are small (€50 per 500 kg) and much smaller than the marginal tax of car weight (up to €800 per 500 kg).

1. Introduction

An increasing number of studies have shown that heavy cars incur substantial car accident externalities on other road users (Evans, 1994; White, 2004; Anderson, 2008; Li, 2010). Heavier cars impose an increased danger to other cars and their occupants.[1] The main finding in the US literature is that the negative external effect of heavy vehicles is *not* internalised (White, 2004; Gayer, 2004; Anderson, 2008; Li, 2010). At the same time, we will see that there are reasons to believe that this finding may not hold for other countries, because the marginal costs are much lower and taxation of car weight is much higher. In the current paper, we examine the external costs of vehicle weight for the Netherlands.

In the Netherlands, the marginal external costs of car weight are likely much less than in US. Note that car weight only has an external effect when *multiple* cars are involved in an accident. Hence, the marginal external costs of car weight depends strongly on the number of multiple-car accidents. It turns out that multiple car accidents are relatively rare in the Netherlands, because car accidents are less common (e.g. due to a lower mileage, minimum age of driving license) and multiple-car accidents are only a small share of car accidents (one contributing factor is that the proportion of mileage driven on highways, where there is a small risk of being involved in a multiple vehicle accident, is about 60% higher in the US). For example, in the Netherlands, each year about 400 inhabitants are the victim of fatal car accidents of which only 10% involve more than one car. By comparison, in the US, which is about 45 times larger in terms of cars, about 30,000 fatal car accidents occur of which about 30% involve more than one car. Hence, per car, the probability of observing a fatality in a multiple vehicle car accident is much higher for each car in the US. This makes it extremely plausible that the marginal external costs of car weight is much less in the Netherlands than in the US.

Furthermore, due to the existence of corrective car taxation, as well as (mandatory) third-party insurance (Edlin, 2003; White, 2004; Li, 2010; Anderson and Auffhammer, 2011), the external costs of car weight are much more likely to be internalised in the Netherlands than in the US. By EU law, car drivers have to be insured for *financial* (material, including hospital expenses) costs imposed on collision partners through obligatory third-party insurance. The no-fault insurance institutional setting essentially allows car drivers to claim financial losses imposed on collision partners from their own or another insurer regardless of fault. The EU minimum insured amount is € 907.560, but the actual minimum insured amount is usually higher. For example, Belgium and the UK require unlimited coverage, whereas in the Netherlands, the insured amount is around € 2.5 million.

Third-party insurance is supplied by private insurance companies that set premiums in a highly competitive market. Third-party

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[1] In Europe, the institutional setting and taxation of cars has resulted in a fleet of cars that are much more homogeneous than in the US. In particular, SUVs and light trucks are rare on European roads. In 2007, the sale of SUV's in 2007 was only 7.1% of private cars, whereas in 2000 it was about 3.5%. The stock of SUV's is less than 5%.

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insurance premiums increase with vehicle weight (as well as mileage and the driver's accident history, but not with the value of the vehicle). For example, we have calculated that in the Netherlands, the average third-party annual insurance premium is about € 50 per 100 kg of car weight.[2] This makes plausible that the external *material* costs of accidents (including hospital expenses), and more specifically the marginal external material costs related to car weight, are largely, and may be fully, internalised.

Internalisation is particularly plausible as moral hazard issues regarding accidents are limited when drivers choose the weight of a car and car accidents premiums depend on the driver's accident history. We emphasise that full internalisation of nonmaterial external costs is *not* the case, because third-party insurance only covers material damage, whereas nonmaterial damage to occupants of the collision partner (minor injuries, serious injuries resulting into disability and fatalities) is not insured in the market.

So, the main question is whether the *non-material* external costs are internalised. Internalisation is plausible because in many countries, car weight is implicitly or explicitly taxed through road and purchase taxation. In the Netherlands, the *annual* road tax depends *explicitly* on vehicle weight. This tax also depends on type of fuel used and province of registration, but roughly implies a marginal annual tax of € 80 per 100 kg. However, recently, specific environmentally friendly cars are exempted from this tax.

The Dutch car purchase tax is an ad valorem tax of about 40%. This implies that car weight is *implicitly* taxed, because purchase price and vehicle weight are strongly positively correlated. Calculations based on a comparison of 10 popular models, suggest that the implied annual tax on weight is about the same order of magnitude as the road tax, so also about € 80 per 100 kg.[3]

In most European countries, at the same time, many cars are subsidised when the car is provided as a fringe benefit, so-called company cars. About 30–40% of all new personal cars are company cars. The average company car is provided as a benefit for a period of 3–4 years. The Dutch fiscal treatment of these cars implies that there is a subsidy on these cars, which is about 30% of the total user costs Gutiérrez-i-Puigarnau and van Ommeren (2011). Because the subsidy is large, the *net* implicit tax on weight (the ad valorem tax minus the lease subsidy) is negative for company cars, implying an annual subsidy of about €40 per 100 kg.

Summarising, the annual marginal tax related to nonmaterial externalities is about €160 per 100 kg for most cars (€80+€80), €80 per 100 kg for specific environmental friendly cars and about €40 per-kg for company cars (€80–€40). The main question is now whether the marginal *external* costs of car weight exceed these levels of taxation.

It is well-known that the annual probability of being involved in an injury is small for the average car. It is also clear from the literature that car weight is an important determinant of accident outcomes. It is however not intuitive to what extent the annual marginal external costs of car weight, which is the product of the annual accident rate and the average marginal externality per accident, are large or small.

In the literature on car weight and fatal two-vehicle accidents, two different statistical approaches are used (Evans, 1994; 2001; White, 2004). The first approach uses only accident data where at least one fatality is involved. It then determines how the ratio of car weight of the two cars affects the probability of a fatality in one of these cars (e.g. Evans, 1994). For reasons that will be become clear in the next section, we will call this the accident fixed effects approach. The other approach, favoured by economists (and us), selects also accidents that do not involve fatalities and then determines how the car weight of both vehicles separately affect the probability of a fatality of a certain car user (e.g., White, 2004). We will call this the standard approach.

In the current paper, we will see that both approaches can be unified. We will see that under certain assumptions, to be discussed later on, the approaches yield identical results. However, only given the standard approach one can estimate the marginal external effect we are interested in. For convenience, we will focus on the logit model, which is useful to describe one type of accident outcome (e.g., a fatality), but our point also holds for the multinomial logit model, applied in this paper, where one distinguishes between different types of injuries. We will also point out that a logit model specification that uses the logarithm of weight is consistent with Newtonian mechanics.

The remainder of this paper is organised as follows. Our empirical approach is explained in Section 2. Section 3 discusses the results, and Section 4 concludes.

2. Empirical approaches to identify the effect of car weight on fatal accident probability

2.1. A standard approach

To explain the standard approach, we will focus on the effect of vehicle weight of both colliding cars on the probability of a fatal accident. We ignore for simplicity the presence of passengers, so there is maximally one fatality per car.[4] We are particularly interested in the external effect of vehicle weight, so the effect of vehicle weight, on the probability of a fatality of the driver of the *other* colliding car. Importantly, in our empirical approach, we will include the effects of vehicle weight on other injuries than fatalities as well.

We assume that we have observations of all (relevant) two-vehicle accidents. Hence, this involves all accidents that potentially lead to a fatality. Each accident is denoted by an indicator j. A car involved in an accident is indicated with 1 or 2. A fatality of a driver in a car is indicated with a dummy indicator Y_{1j}. Further, we assume that, for an accident j, the probability of a fatality of driver 1 with characteristics X_{1j} (e.g., gender) and weight m_{1j} given a collision with another driver with characteristics X_{2j} driving a car with car weight m_{2j}, can be described by a logit model, where the effect of car weight is included in logarithm. So, we assume that:

$$\text{Prob}(Y_{1j}=1)=e^{w_{1j}}/(1+e^{w_{1j}}), \tag{1}$$

where

$$w_{1j}=\beta\log m_{1j}+\gamma\log m_{2j}+\theta_1 X_{1j}+\theta_2 X_{2j}+\alpha_j$$

Here, α_j denotes any effect that is specific to the accident, so it refers to accident-specific fixed effects. Note furthermore that we use the *logarithm* of car weight, in line with Newtonian mechanics which describe that the ratio of car weight of the cars involved determines the outcome. So, Newtonian mechanics analysis implies that $\beta=-\gamma$ if mass of the car does not include additional safety measures (Evans, 1994). However, even given these measures, it will be true that $\beta<0$ and $\gamma>0$. So, the probability of a fatality falls with the mass of the own car and increases with the

[2] We have calculated this premium given the average annual number of kilometres (about 15,000) and an accident-free period of three years and compared premiums for car weights between 900 and 1900 kg.

[3] We have first collected information on purchase prices and weight using information from 10 models. We then calculated the implicit annual tax on weight assuming that cars are linearly depreciated within 10 years. This results in an annual tax of about 4% of the purchase price.

[4] In the empirical analysis, the presence of injured passengers will be taken into account.