Car Taxation and Households’ Car Choice:

Evidence from Denmark

Katrine Marie Jakobsen*

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Abstract

This paper studies how households' car choices and car prices respond to car taxes. Governments impose taxes to regulate and influence car usage and to raise tax revenue, but evidence of the effects of such policies is scarce. In Denmark, like Holland, Norway, and France, new cars are taxed the first time they are registered. In November 2015 this tax was reduced strongly for medium and large cars. The tax change was announced and unexpected. I find that the average retail price of new cars bought by Danish households increases by 4 percent in the year after the tax reduction. Furthermore, my results suggest that the reduction in the registration tax is fully reflected in final car prices and that car dealers do not increase retail prices in response to the reduction.

*Jakobsen: University of Copenhagen and CEBI. The activities of Center for Economic Behavior and Inequality (CEBI) are financed by a grant from the Danish National Research Foundation, kmtj@econ.ku.dk.
1 Introduction

There are over 252,000,000 passenger cars in use in the European Union. Because car usage is associated with externalities in the form of congestion and pollution, governments tax car usage to influence households’ decision of which car to buy and how much to drive. Also, governments might tax cars to raise revenue for financing public expenses. Each year over 400 billion Euros is collected by European governments through taxes on cars, fuel and road taxes. In 2016 revenue from car taxes as a share of GDP was 2.4% in Denmark, while in Germany, France, and Sweden was around 1.5%. These taxes are paid by European households and firms and the amount corresponds to three times the total budget of the European Union. No matter the reason for taxing car usage, when governments impose taxes on cars it becomes less desirable for households to buy expensive cars and to drive a lot. But how does that affect the welfare of households? Does that make households’ buy less expensive cars? Drive less? This is important to know for policymakers in order to design effective policies. Estimating behavioral responses to taxes is one of the core topics in Public Finance. though much of this literature focuses on responses on taxable income and labor. However, estimating responses to sales taxes and consumption-based taxes are equally important.

Answering these question is difficult due to several empirical challenges. First, to study how household responds to taxes targeted car usage we need individual data on households’ car choices. And while most countries now collect data on taxable income and labor supply, very few countries collect micro data on large durable consumption goods like car purchases. Second, we need compelling variation in car taxation that allows for the estimation of causal effects.

In this paper, I study how taxes on car purchases affect households’ car choice. Furthermore, I study the tax incidence of such purchase taxes and how the tax burden is shared between the households and the car producers. My laboratory is Denmark, which provides data and quasi-experimental variation that allows me to overcome the challenges described above.

Through an administrative data set from the Tax Authorities, I have information on all new cars bought by Danish households since 2013. I observe detailed technical information, as well as sale prices and taxes for every new car.

In Denmark, the consumer must pay a registration tax the first time a car is registered. This type of tax is not uncommon, and countries like Norway, Finland and Holland have similar registration taxes for cars. The tax depends on the retail price of the car. Until November 2015, the marginal tax rate on medium and large cars was 180%. The Danish government implemented a large and unexpected change to the registration tax - decreasing it to 150%. I utilize this tax reduction as an exogenous variation. I document that this tax reduction was completely unanticipated by documenting google searches and newspaper coverage in the relevant time frame. This allows me to overcome the general concern in these type of anticipation-effects contaminating the results when estimating responses to consumption or sale taxes. And so I estimate the impact of the registration tax reduction on households’ car spending using a difference-in-difference design where I compare car spending of households affected by the tax reduction.
to car spending of households unaffected by the tax reduction.

My main findings are the following. First, I find that the tax reduction has caused households to buy more expensive cars of higher quality than they would have absent the tax reduction. So much, that this effect is more than enough to offset the negative mechanical impact on government revenue from lowering the tax. Second, in the year after the tax reduction car dealerships has not increased retail prices as a consequence of the tax reduction. This implies that the incidence of the registration tax is on the consumer side. In Denmark, the import (or retail) prices of cars have been low historically compared to other European countries, which can be attributed to the high tax level. I show, that the full increase in household car spending is explained by an increase in the quality level of the cars sold. Thus, I find no indication that either car sellers increase prices for a given quality level, following the tax reduction. This implies, that the full burden of registration tax is carried by consumers and that the reduction solely benefits car buying households. Thus, the tax reduction can be said to have improved economic efficiency, under the assumption that other taxes (ownership and fuel taxes) offsets the negative impacts of car consumption.

Taxes on cars can affect households’ decision of whether to buy a car or not, when to do so, which car to buy, and how much to drive in it. In (Klier & Linn, 2015) they study the effect of implementing CO2 based taxes in France, Germany, and Sweden on the total number of car registrations and find that this number goes down especially in France. I don’t rely on aggregate data, and I can observe the actual sale prices and technical specifications of the cars that are sold before and after a tax reduction. Furthermore, I can document no price-effects of the tax reduction. These and other studies ((D’Haultfoeuille et al., 2014), (Gutierrez-i Puigarnau & Van Ommeren, 2011), (Mulalic & Rouwendal, 2015), and (Asplund et al 2018)) generally find that households respond quite strongly to tax policies on the car market.

Some relatively recent papers study behavioral responses and incidence of consumption taxes on non-durable goods such as food (see (Gaarder, 2018)), while less is known about durable goods such as cars. The standard assumption would be that consumers carried the full burden of taxation through higher prices. However, in the presence of market imperfections tax changes might lead to over or under-shifting. As the car market is characterized by high entry-costs and few but large manufactures, predictions on the incidence of the registration tax are not straightforward. (Carbonnier, 2007) study the incidence of VAT on cars in France, and find that consumers and producers share the burden of sale taxes. A challenge is this paper is that it relies on aggregate data and that they cannot control for whether there increase in prices after the VAT reduction is caused by price or quality increases.

The remainder of the paper is organized as follows. Section 2 describes the data and the tax reform and documents the evolution of households’ car consumption and car prices in leading up to the tax reform. In section 3 I present quasi-experimental evidence on the effects of the registration tax on households’ spending on new cars and on car prices and section 4 concludes.
2 Data and Background

2.1 Data

My empirical analysis is based on data from the Danish Motor Register (DMR). This register contains information about all cars in Denmark from 2013-2016. For new cars, I observe the first date of registration, the personal identifier of the owner, and a range of characteristics of the car. I observe brand and model specifications, as well as the retail price, the registration tax paid, and the final sale prices. As I observe the owner of each car in the DMR I can link this data-set about car-ownership to standard other Danish registers. These registers contain information on income, education, age, etc.

2.2 Car Taxation in Denmark

Car taxation in Denmark is threefold. It consists of taxes on gasoline, bi-annual ownership taxes, and the registration tax. The registration tax is paid the first time a car is registered in Denmark. The registration tax was introduced in 1925, originally to improve the Danish trade balance. Until 2016 the Danish registration tax was among the highest in the world of such taxes. The registration tax generates around 20,000,000,000 DKK in tax revenue each year and is the largest component of the three types of car taxes. It is fully salient since consumers only observe the after-tax price at the car dealerships.

The registration tax is progressive, with two brackets. In 2015 the tax rate in the bottom bracket was 105% while the tax rate in the upper bracket was 180%. In November 2015, the Danish government announced that the top tax rate would be reduced to 150%. The marginal registration tax is 105% of the value of the vehicle up to 82,800 DKK in 2015. Hereafter the top tax rate applies up to the full retail price of the car. Cars in the bottom bracket, taxed at the lower rate, would be mini and small cars like Volkswagen UP! and Peugeot 208. The VAT is then added on top of the registration tax. And so the final price of a new car is a piece-wise linear function given by:

$$\text{final price} = (1 + \text{VAT}) \times \left((\tau_{\text{low}}) \times \min(K_t, \text{retail price}) + \tau_{\text{high}} \times \max(0, \text{retail price} - K_t) + \text{retail price}\right)$$

(1)

$\tau_{\text{low}}$ is the tax rate on the retail price below the threshold and $\tau_{\text{high}}$ is the tax on the retail price above the threshold.\(^1\) The registration tax also applies to other types of vehicles such as motorbikes and auto campers, however with different kinks and tax rates. In this paper, however, I only consider gasoline and diesel cars owned by private Danish households.

While the tax rate was decreased quite substantially in 2015, the threshold remained constant throughout the period only adjusted by the inflation rate.

The tax decrease was unanticipated. In Figure 1 I show the number of newspaper articles containing

\(^1\)There are reductions are given for certain safety equipment and fuel efficiency. 4,000 DKK pr. every km/l that exceeds 16 km/l for gasoline cars and 18 km/l for diesel cars. Rebate of 200 DKK per seat belt alarm (maximum of 600 DKK, in total).
the word ’registration tax’\textsuperscript{2} in all Danish newspapers and Google searches about the registration tax in the months leading up to the announcement of the tax decrease. If the tax change had been anticipated there would have been an increase in the news coverage and Google searches of the registration tax leading up to the presentation of the tax decrease. However, it is not the case, the media attention is completely stable until the day of the announcement of the change. Because of this, I can use the tax reduction as an exogenous variation to identify households’ behavioral response and effects on car prices from the registration tax decrease. Had the tax decrease been anticipated potential car buyers would most likely delay their purchase in order to benefit from the reduction, which would complicate my analysis. Anticipated tax changes can be expensive to governments, as consumers generally show strong responses by increasing purchases of durable goods prior to tax changes.

2.3 Car Prices in Denmark

Cheaper cars for Danish households! This was the selling point of the tax reduction after it had been implemented. Generally, retail prices of cars in Denmark have been known to be low compared to other countries, exactly because of the high registration tax. A report from the European Commission from 2011 show that final car prices in Denmark are on average 60% higher than in the rest of Europe. However, the retail prices are among the lowest.\textsuperscript{3}

Taxes generate deadweight losses and the study of tax incidence is concerned with how this burden from taxation is shared between the consumption and the supply side of the market. We know that the side of the market formally paying the tax is not necessarily the side of the market who bearing the economic burden of the tax. Therefore, lowering the registration tax could induce car dealerships or manufactures to increase retail prices to extract economic surplus from deadweight loss. Exactly because retail car prices have been among the lowest in Europe, an unintended side-effect of the registration tax reduction could be that retail prices over time would increase so that Danish households actually didn’t get cheaper cars, as announced by the Danish politicians.

The standard assumption would be that taxes are fully shifted on to the consumers. However, market imperfection can lead to both over-shifting and under-shifting of sales taxes to the consumers. Figure 2 shows the general consumer price index as well as a Price Index for New Cars computed by Statistics Denmark. The graph shows that the general consumer price index and the index for new cars followed the same path up to the point of the tax reduction where-after general consumer prices increases while prices for new cars decreases. This suggestive evidence indicates that quality-adjusted after-tax prices actually did decrease after the tax reduction and that the decrease did indeed benefit car-buying households that bought a car after the reduction.

\textsuperscript{2}’Registreringsafgift’ in Danish
\textsuperscript{3}http://ec.europa.eu/competition/sectors/motorvehicles/prices/200605a.pdf
2.4 Households’ Car Choices

When a family considers buying a car it searches the market and chooses which car to buy. A Mercedes is more expensive than a Citroen and as with any other consumption choice, the household has a trade-off between buying a more expensive car and consuming more of other goods (including leisure). The family will buy the car that yields the highest utility-level taking the registration tax as given.

However, changing the registration tax will change this trade-off, given that the tax reduction is reflected in the final prices.

To provide context, I show graphical evidence of households’ car consumption between 2013-2016 at the monthly level. Figure 3 shows the number of new car registrations as well as average prices, weight and registration taxes paid on these new registrations. On average, around 8,000 new cars are registered each month. However, the graph shows that the number of registrations fluctuates over different months. However, there is no indication of an either in- or decreasing trend in the number of new registrations over time, as depicted in Panel A. However, as shown in Panel B there is a clear increase in the average final price of the new cars bought by Danish households. Prices can increase for two reasons. Due to inflation or because households buy larger cars of higher quality. Therefore, I also plot the average weight of new registrations over time. This is shown in Panel C. There is a clear increase in the weight of cars bought which implies that at the increase in prices shown in Panel B cannot because only by inflation. Panel D shows the average registration tax of the new registrations. It indicates that the average registration tax has slightly increased following the tax reduction.

The increase in the price of cars bought by Danish households reflects that the distribution of cars has shifted to the right. This is shown in figure ??.

3 Effects of Registration Taxes: Evidence

3.1 Empirical Strategy and Household’s Car Choices

Denmark used to tax cars at a very high rate. To identify the effect of the tax reduction on household car choices I utilize the 2015 tax reduction. Though the tax rate above the threshold was reduced from 180% to 150% the tax rate below, at 105%, remained unchanged. This feature of both the design of the registration tax and the reduction allows me to set-up a difference-in-difference strategy where I compare the evolution in households car choices of cars subject to the high and the low tax rate. Therefore, I compare households’ buying cars with a retail tax price above the kink (treated) to households buying cars with a retail price below the kink (non-treated).

The underlying assumption for this strategy is that the trend in the retail price of cars households’ buy, would have been the same absent the tax reduction. As already shown in Figure 3 Panel B and Panel C both prices and quality levels of new cars bought by households has increased over time. Now, I split the sample by segment comparing the retail-price evolution of cars with retail prices above and below the threshold. I show the monthly average retail prices for each segment, normalized to the month
of the tax reduction. ?? shows that cars above and below the kink have increased slowly over the years and that the average retail price of cars below the kink is about 10.000 DKK below the kink throughout the period. In Panel B I index the evolution to November 2015, the month of the tax reduction. This graph clearly shows that retail-prices of cars above and below the kink followed the same trend prior to the tax reduction. There is a lot of volatility across the months, but on average the follow the same path.

Immediately after the reduction there the trend shifts for cars with pretax prices above the kink. This indicates, that there is a clear effect of the tax reduction causing households to buy cars with higher pretax prices right after the reduction. The analysis is based on a repeated cross-section of all new cars the first time they are registered in Denmark between 2013-2016 giving me 3 pre-reform years and 1 post-reform year.

The regressions are observed at a monthly level. My results are based on the following regression equation:

$$\log Y_{it} = \sum_{j \neq 2015-11} \beta_{YMMj=1}^{C} + \sum_{j \neq 2015-11} \beta_{YMMj=t_i}^{T} + \nu_{it}$$

where $Y_{it}$ is the retail price of a given car $i$ at time $t$, $YearMonth_j = t$ is a dummy when year-month equals $t$, $Treat_i$ is a dummy equal to one when car $i$ belongs to the treatment group.

For each outcome, I plot the reduced-form effect of the registration tax reduction at time $t$ ($\hat{\beta}_t^T$). These graphs are shown in Figure 5.

I find that households buying a car with a retail price above the kink increases by Cars with 5% higher retail prices. This effect is caused by the tax reduction. Quality, measured by weight, increase significantly for the cars with a retail price above the kink registered after the tax reduction. When estimating the effect of the reduction on a variety of quality measures hand side I find similar results.

I find that cars with a retail price above the kink sold after the tax reduction are on average 3 percent heavier than cars sold before the tax reduction.

### 3.2 Effects on Car Prices

The suggestive evidence from price index from statistics’ Denmark already indicated that the tax reduction actually did decrease the prices of new cars in Denmark. However, to further investigate this question I utilize the fact that my data set includes a variety of technical specifications about all the new car registrations.

Each year new car manufacturers introduce new car models and variety of already existing models. However, many model-variety combinations will also be in the market over a longer time period. I use the fact that some car-model-variety are sold in the market both 12 months prior to the tax reduction and 12 months after.

To investigate the effect of the tax reduction on retail prices I the retail price based on a set of technical characteristics for all new cars registered in the 12 months prior to the tax reduction. From these estimates, I then predict the retail price of cars sold in the 12 months following the tax reduction. If
car sellers did increase retail prices following the tax reduction I would find that my retail price predictions after the tax reduction would be too low compared to actual retail prices.

And so, I run the following regression on cars sold before the tax reduction:

\[
\text{Retail Price}_i = \alpha + \beta X_i
\]

Where \( X_i \) is a long set of technical characteristics including fuel type, engine size, engine, power, brand, and model fixed effects, number of airbags etc. Based on this set of \( \beta \)'s I predict the retail price, Retail Price for cars sold in the 12 months before and after the tax reduction. Then I compute the prediction error as:

\[
\text{Prediction Error}_i = \text{Retail Price}_i - \text{Actual Retail Price}_i
\]

In Figure 6 I show the distribution of prediction errors before and after the tax reduction. The figure shows that the distribution both before and after is clearly centered around zero and that the distributions, in general, are very similar. If car sellers had increased retail prices to extract some of the surpluses from the tax reduction the distribution of prediction errors would have shifted to the left after the tax reduction.

It should be noted, however, that this is solely a short term effect - looking at one year after the tax reduction. Due to the cost of resetting prices, such as menu costs, it might be the case that retail prices for a given quality level over time would increase in Denmark.

4 Concluding Remarks

In this paper, I study the effect of a registration tax reduction on households car consumption and on prices for new cars. The main findings are the following. First, the tax reduction has caused households to buy significantly expensive cars of higher quality. Second, in the year after the tax reduction car dealerships has not increased retail prices as a consequence of the tax reduction. This implies that the incidence of the registration tax is on the consumer side.

Thus, the tax reduction can be said to have improved economic efficiency, under the assumption that other taxes (ownership and fuel taxes) offsets the negative impacts of car consumption.

The results of this paper should be interpreted in light of the limitations of my analysis. Three things are worth noting here. First, the decreases in the registration tax might have unintended environmental consequences when households change their consumption patterns. Second, I only consider the effects of the tax reform one year after it’s implementation. Thus, I really only consider the short term effects. In terms of the behavioral responses, it seems reasonable to assume that the increase in demand for cars of higher quality with higher retail prices is a permanent effect. However, in terms of the incidence it likely that prices are sticky, so that car dealerships and manufacturers will increase retail prices when selling cars to Denmark in the longer run. Thirdly, I am not able to detect the spill-over effects from the market of new cars to the market for used cars or leasing cars.
References


Figure 1: Anticipation of Tax Decrease

Notes: The figure shows the number of news paper articles (left hand side) the Google search activity (right hand side) about the registration tax in the months leading up to the reform. The figure document that the tax change was unanticipated as there was no build up in media attention on the registration tax prior to the announcement of the tax change.
Notes: This figure shows the general consumer price index and the price index for new cars as calculated by the Danish Statistical Agency (2015=100). Source: Statistics Denmark, TABLE: PRIS111
Figure 3: Households Car Consumption over Time

Notes: This figure describes Danish households car consumption at the monthly level over time. Panel A shows the evolution of the monthly number of new car registrations. Panel B shows the average total prices of these cars and Panel C shows the average weight. Panel D shows the average registration tax.
Notes: This figure shows the distribution of retail prices among new car registrations in 2013-2016. The distribution is coinciding in the three years, 2013-2015, prior to the tax reduction and shifted to the right in 2016, the year after the tax reduction, indicating that households are buying cars with higher retail prices.
Notes: This figure shows the average retail price of new cars bought by Danish households with retail prices above and below the threshold. Panel A shows the actual levels while Panel B shows the average retail prices, indexed to the month of the tax reduction.
Figure 5: Reduced-form Evidence on Retail Price and Weight

Panel A: Above and Below the Kink

Effect one year after: 0.042 (0.006)

Panel B: Above and Below the Kink, Indexed

Effect one year after: 0.019 (0.004)

Notes: This Figure shows the reduced-form effect of the tax reduction over time on household’s car choices. Panel A shows the effect of the retail price, Panel B show the effect on final prices, and Panel C show the effect on weight.
Notes: This Figure show the distribution of prediction errors before and after the tax reduction. The predicted retail price of a car is given by the estimated effects of a detailed set of technical car characteristics on retail prices, based on regressing retail price on car characteristics before the tax reduction.