Winners and Losers from an Announced Excise Tax Hike: Tesla in Denmark

Marcus Asplund CBS
David Jinkins CBS
Chandler Lutz CBS
Gyorgy Paizs*

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1 Introduction

In December of 2015, the Tesla Model S – an expensive, fully electric luxury sedan – was the best-selling personal vehicle in Denmark. It is unusual that a luxury car was a best seller. It is even more unusual that it was an electric car. Indeed, this was the first time an electric car had topped sales charts in any major market (Electrek 2016).[1] Immediately following the sales surge was a dramatic sales ebb. Very few new Tesla's were sold in the first six months of 2016. The cause was a tax hike passed by the Danish parliament in October 2015. The law ended a registration tax exemption for alternative-fuel vehicles. Buyers rushed in to purchase and register their Tesla's before the new tax regime took effect on the 1st of January 2016.

The Danish government chose to announce the tax change well before the change was implemented. A natural question is which parties benefited from the way the tax change was rolled out. Using data we scraped from the most popular online used car marketplace in Denmark, we will argue that there is little evidence of speculation on the used car market. Controlling for many observable characteristics, the price of used Tesla's increased in this period. Instead, our evidence is consistent with another story. Consumers who were planning on upgrading to a newer model of Tesla in 2016 instead upgraded in 2015, listing their older model on the used car marketplace. There it is likely that final consumers of new Tesla's gained from the tax rollout. They were able to avoid the new tax by purchasing in 2015. The big loser in our calculations is the government. By announcing the tax change in advance, the government

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[1] Tesla was producing only 1000 Model S's a week in 2015 https://transportevolved.com/2015/05/06/tesla-motors-posts-q1-2015-losses-due-to-strong-dollar-high-capital-expenditures-hits-1000-carweek-model-s-production/

lost revenues from sales. We perform a rough calculation, and find that the government's losses were on the order of hundreds of millions of Danish Kroner (tens of millions of Euros). Our baseline estimate is that the government lost more than 350 million Danish Kroner.

There is a large literature which studies the consumption response to overall tax changes and the anticipation of tax changes.[2] There are fewer studies which focus the effect of sales taxes on consumption. Consistent with our data, Cashin and Unayama (2016) find that Japanese consumers increased durables consumption just before a VAT increase. In European data, Büttner and Madzharova (2016) find an elasticity of short-run durable purchases to VAT increases of one to five percent. While our findings are consistent with this literature, we focus on a much narrower tax change – an increase in the tax on only new electric cars. We use a close substitute, used Teslas with no kilometers on the odometer to study the role of speculation in tax arbitrage, and measure the overall effect on government revenues of announcing the tax hike well in advance. As in other recent studies we find that the anticipation of a sales tax increase has a significant effect on purchases of durables. This finding lends empirical support to a theoretical literature emphasizing how scheduled VAT or sales tax hikes can be used as unconventional fiscal policy to stimulate the economy without government borrowing (Feldstein, 2003; Hall, 2011; Correia et al., 2013). In our application, the tax hike on electric vehicles likely led to more electric vehicles on the road in the short run.

2 Background

The tax in Denmark for registration of new private vehicles is among the highest in the world. The current "sticker" sales tax is 150% of the value of a vehicle.[3] Alternative fuel vehicles, including electric vehicles, were however exempt from the registration tax until 2016.

There are several important dates for our study. The tax exemption for alternative fuel vehicles was set to expire in 2016. The exemption was widely expected to be extended, particularly if the Social Democrats remained in power.[4] A new government led was formed after an election in June of 2016, which resulted in a surprise victory for the right, especially the Danish People's Party.

[2] For a large and recent survey, see Attanasio and Weber (2010). Typically, these studies focus on tax changes which affect income more broadly, and aim to test the permanent income hypothesis. There is surprisingly little consensus in the literature about whether consumers react to anticipated changes in income. To pick out a few, Poterba (1988); Parker (1999); Mertens and Ravn (2011) find little affect of the anticipation of income changes on consumption, while Browning and Collado (2001) find that consumers do smooth consumption. Hsieh (2003) finds that consumers smooth with respect to some income shocks, but not others.

[3] The standard sales tax was actually lowered in 2016 from 180% to 150%. Details of the tax are quite complicated, as it is somewhat progressive and includes many rebates for various features. The actual assessed tax is often significantly lower than the sticker price, especially for small, inexpensive personal vehicles.

[4] There was some differences in party positions. The incumbent Social Democrats and other parties on the left wanted at least a year's extension on the tax.

The issue of taxes on alternative-fuel vehicles came to the fore of public debate in September of 2015 with a number of Danish newspaper op-eds. On the 9th of October a bill was passed in the parliament in which standard electric cars would gradually lose their tax exemption with phase in beginning in January 1, 2016.[5]

3 Data

Our analysis will rely on two major data sources. The first data source is information on used cars in Denmark scraped from the most popular Danish used car forum, Bilbasen.dk. We have scraped the universe of Tesla advertisements from 1st October, 2015 to the 1st of May 2016. We started scraping the data in half-hour increments just after the debate about the electric vehicle tax started heating up at the end of September, 2015. Each advertisement in our data set include the cars price, production year, odometer reading, and other important characteristics relevant for Tesla such as the battery package, performance indicators and engine type (single or dual-motor).

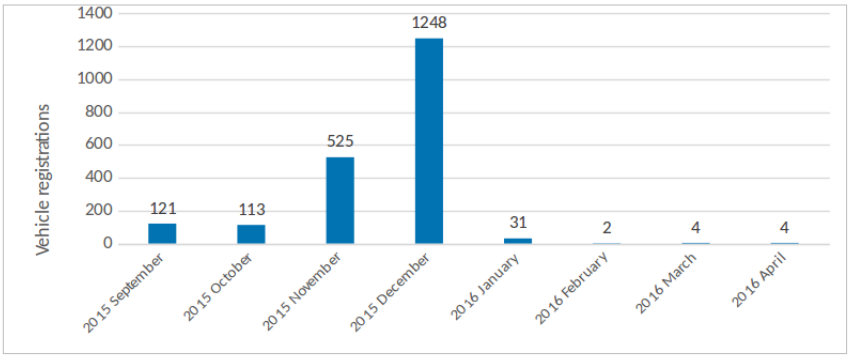
The second major data set, provided by the Danish Car Importers Association, includes monthly aggregates of personal vehicle registrations from 2015 to the beginning of 2017. The data details registrations by make and model. For additional information about how the data were collected and cleaned, see the Online Appendix.

3.1 Descriptive statistics

Figure 1 presents the monthly time series of new Tesla's registered in Denmark around the change in tax law. Below the figure, we list the annual number of registrations from 2013-2016. There is a swift rise in the number of registrations leading up to December 2015, and then a dramatic fall beginning in January 2016. Only 176 new Tesla's were registered in the calendar year 2016, only 6% as many as were registered in 2015. The reader will recall that the tax on electric vehicles rose again in 2017, and indeed we see a similar but much smaller increase in registrations in November and December of 2016.

Turning to the used Tesla market, our data includes 998 advertisements for 502 unique Tesla Model S vehicles, a relatively large number considering that 3310 Tesla Model S were registered in Denmark as of the end of 2015. Table 3.1 presents descriptive statistics for our used Tesla listings. The mean asking price for our used Tesla is quite high at 750,748 DKK or around 100,000 Euros. The mean odometer reading is 22,661, which is reasonable considering that the Model S was first sold in Denmark in 2013. The dummy "new" flags Teslas which have never been driven. These make up 8% of our sample. Around 96%

[5] In addition, there was to be an even higher tax on luxury electric vehicles, basically targeting Tesla, which was struck down by the EU before the tax change was implemented. For more details, see the Online Appendix.



	2013	2014	2015	2016
Tesla	112	460	2738	176

Figure 1: Registrations of new Tesla automobiles in Denmark

Variable	mean	sd
Price	750,748	148,128
Kilometers	22,661	17,610
New	0.083	0.276
Oct9_dummy	0.964	0.187
Jan1_dummy	0.496	0.500
Observations	998	

Table 1: Key variables, dates refer to listing date

of the Teslas we have were listed after October 9th, 2015, and around 50% were listed after January 1st.[6]

Figure 2 includes both the stock and flow of used Tesla advertisements in our data. The number of used Tesla's listed grows significantly from October to December 2015, then falls around the holiday season. In January the number of ads grows again and ends up stabilizing at around 110 used Teslas for sale in the Spring of 2016. The bottom part of Figure 2 shows listings and delisting of Tesla Model S. There are around 40 autos either listed or delisted each week at the end of 2015, and around 20 autos listed or delisted each week in the Spring of 2016. The market appears to be quite liquid.

4 Speculation or upgrading?

In the previous section, we showed that the market strongly responded in anticipation of the new tax. In this section we present evidence for two possible reasons for the dramatic increase in Tesla Model S sales in the final months of

[6] We drop the 30 listings observed on October 1, our first day of scraping.

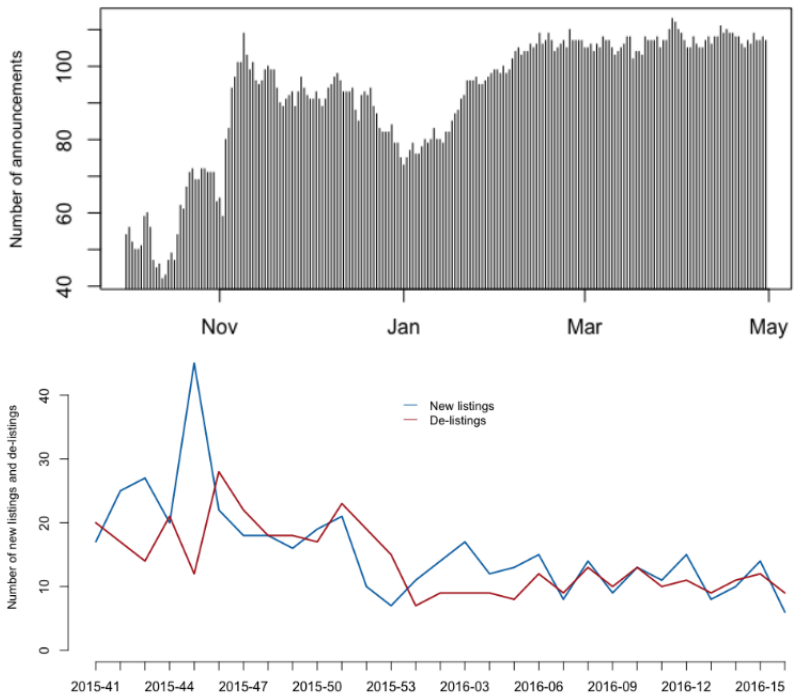


Figure 2: Total Tesla Model S ads (daily, top) and listings/delistings (weekly, bottom)

2015. The first is that dealers or other parties were speculating by buying and registering Teslas in 2015 to be sold in the used market in 2016. The second is that consumers who planned on upgrading their personal Tesla in 2016 or 2017 instead bought and registered in 2015 in order to avoid the increased sales tax. We present several pieces of evidence that suggest there was little or no speculation, and instead the major driver of the sales was replacement. First we show that there was an economically and statistically significant increase in the price of used Teslas in 2016 relative to similar Teslas listed in 2015. This is evidence against speculation, as speculators should have arbitraged this price increase away in advance. Secondly, we show that the number of new used listings, that is autos which had never been driven, did not increase after January 1st. Again this is evidence that speculators did not buy new Teslas with the aim of selling them after the tax increase.

Figure 3 presents the simple discontinuity in mean prices of cars listed around the turn of the new year in 2016. [7] Table 3 presents standard Wald tests for differences in mean. The first row is based on the optimal bandwidth suggested

[7]For this exercise we use calendar weeks which begin on Sunday, so the discontinuity is actually the week beginning Sunday the third of January, 2016. Only three Teslas were listed on the first and second of January, 2016

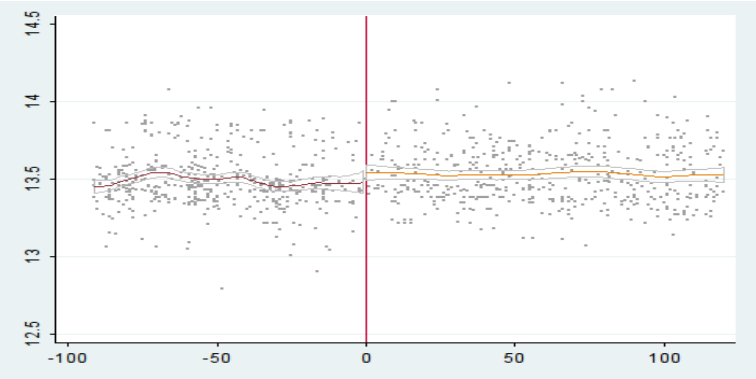


Figure 3: Log price discontinuity of used Tesla Model S listings around January 1, 2016

in Imbens and Kalyanaraman (2012) and implemented by Stata's rd command. The second row is half and the third twice the optimal bandwidth. We find the price of listings increased around 62,000 DKK or 8000 Euro around January 1st. The point estimate is even larger in logs (14% increase), but loses statistical significance.

Table 2: Log price reg discont

	(1) price	(2) logprice
lwald	62262.5**	0.146
	(27584.1)	(0.134)
lwald50	42102.7	0.0770
	(40328.2)	(.)
lwald200	52745.3***	-0.0594
	(20316.2)	(0.133)
N	998	998

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Wald test for used Tesla price discontinuity around first January 2016

Another way to look at price changes is to run hedonic regressions in prices. Table 4 contains results for all listings, as well as last observed listing for each unique Tesla Model S. The last listing is more representative of final sales prices, and all listings are more representative of what sellers believe about the market. Standard errors are heteroskedasticity robust for only final listings, and clustered at the unique automobile level for all listings. Not all of the coeffi-

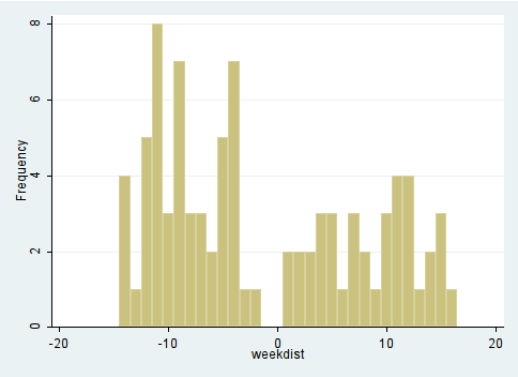


Figure 4: Listings of used new Tesla Model S by week around January 1st, 2016

cients are statistically significant, but they are all in the same direction. Teslas with observably similar characteristics were listed at about 27,000 DKK or 3.5% higher prices on average after January 1st. All other coefficients have the expected sign. Used Teslas with zero on the odometer were worth around 47,000 DKK more on average after January first. The trend in day number is negative because an older used car is worth less, all else equal.

We also find evidence that the number of listings for used Teslas with zero on the odometer (used new Teslas) does not increase. One might have expected that speculators would have bought new Teslas in 2015 and sold them in 2016 without ever driving them. Figure 4 is a histogram of used new cars listed by week. There is no jump in used new cars in 2016 relative to 2015.

5 Tax and transfer effects of sales tax announcement

In this section, we ask how much additional tax revenue would have been generated and what the effect on car purchasing behavior would have been had the government made a surprise announcement of the tax hike on the 1st of January 2016, rather than announcing the change in advance. The additional tax revenues of a surprise announcement would have come through two channels. First, some Tesla purchasers would have bought anyway at the higher prices, and paid a 20% sales tax. Second, other consumers would have instead bought gasoline-driven luxury cars and paid a 150% sales tax.

It is important to admit at the start that this is a extremely rough exercise, and will depend on a number of strong assumptions. Rather than a formal estimation, this part of the paper should be thought of as a Fermi experiment to calculate the correct order of magnitude. We need to know (1) how many Tesla Model S would have been sold in 2015 if there were no tax change, (2) how many consumers would have bought Teslas even after a rise in taxes, (3)

	(1) price	(2) price	(3) logprice	(4) price
jan1_dummy	26918.6** (12877.0)	23696.6* (13131.3)	0.0354* (0.0181)	17908.4 (14731.4)
oct9_dummy	14850.1 (14064.1)	15865.4 (14026.8)	0.0166 (0.0209)	2320.9 (21711.6)
new	26777.7* (13682.6)	8608.7 (14221.8)		8801.6 (16500.7)
jan1_dummy×new		47021.4* (28199.0)		67717.5* (37189.3)
day trend	-445.6*** (102.9)	-446.5*** (102.7)	-0.000596*** (0.000137)	-375.8*** (114.6)
kmeters	-1.275*** (0.252)	-1.279*** (0.251)		-1.423*** (0.262)
logkm			-0.0395*** (0.00701)	
dualmotor	140471.7*** (9718.3)	140252.8*** (9769.0)	0.168*** (0.0125)	137775.7*** (9659.5)
70.battery	-62232.4*** (17879.2)	-60619.4*** (18131.7)	-0.0625*** (0.0234)	-55315.7** (23907.5)
85.battery	88282.4*** (12229.4)	89259.5*** (12414.5)	0.151*** (0.0180)	94717.9*** (20890.9)
90.battery	240291.1*** (28685.8)	234845.9*** (28165.3)	0.235*** (0.0330)	240612.7*** (32804.3)
performancepackage	81109.0*** (7009.6)	79777.9*** (6944.6)	0.0954*** (0.00926)	88014.3*** (6921.9)
signaturemodel	36898.3* (19328.8)	35741.3* (19149.8)	0.0645** (0.0322)	27571.1 (22259.9)
2014.modelyear	33935.4** (14558.9)	33788.9** (14613.9)	0.0667*** (0.0251)	35371.9** (17546.1)
2015.modelyear	98230.2*** (16425.5)	99297.2*** (16497.1)	0.162*** (0.0263)	105165.7*** (19524.7)
2016.modelyear	133000.5*** (25745.1)	123413.0*** (27013.5)	0.179*** (0.0379)	93954.8** (37824.9)
_cons	516491.3*** (27259.7)	516732.2*** (27281.7)	13.51*** (0.0829)	522882.7*** (41118.2)
N	998	998	915	502
Included listings	All	All	All	Only final

Robust/clustered standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Hedonic regression of price on characteristics

how many consumers would have instead bought another type of car, (4) which types of car they would have purchased, and (5) how many consumers would have decided not to purchase a car at all.

We calibrate using demand elasticities from Berry et al. (2004) estimate of American demand for automobiles. This study is a standard reference in the literature in discrete choice estimation. BLP estimate that the mean price semi-elasticity of demand is around -4%. That is, if the price of a car increases by 1000 1993 USD (10,000 2015 DKK), there will be a 4% decrease in the demand for that car. The price elasticity of new car purchases is -0.4%. That is, if the price of Tesla model S goes up by 10%, there is a -0.04% decrease in the overall number of new cars sold. These two parameters together help us infer how a Tesla price increase will reduce the number of new Tesla purchasers, and how many of those who do not purchase instead buy another model of car.

In six months prior to October 2015, there were 113 Tesla Model S sold per month. Assuming that this trend would have continued, there were 1507 "excess" Teslas sold because of the tax introduction. To compare, we would have only predicted 1356 sales in all of 2015 can there been no tax change. Rather than use the sticker price of a new Tesla, it is more accurate to use the mean price of final listings of used new Teslas from our data since anecdotally the standard Model S is missing expensive features which many customers add on. This price in our data is 933,000 DKK. We assume that Denmark is small enough that Tesla is not pricing to Denmark and the price remains the same after the tax is assessed.

There were 233,616 new car registrations in 2014.[8] Using our elasticity formula, if the price of a Tesla goes up 20%, we expect the number of new cars sold to fall by 0.08%, or 187 cars. The government gets no extra revenue from these missing sales. Using our assumption of 933,000 DKK, our semi-elasticity of -4%, and our conversion of 1000 1993 USD to 10,000 2015 DKK, a 20% increase in the price of a new Tesla implies a $933,000 \times 0.2/10,000 \times -4 = -74.6\%$ drop in Tesla Model S sales. Since we have 1507 excess sales, this implies that Tesla still would have sold 382 Tesla Model S with tax revenue on each of 186,600 DKK.

Finally, we need to account for the other 938 car sales. Since we do not have data on prices and characteristics of other options in the car market in 2015, we must assume a substitute for Tesla Model S. There are no other luxury electric cars in the market. Instead we suppose that consumers switch to another luxury automobile, and as a model we choose the Mercedes C-class plug-in hybrid which went on sale in Denmark in 2015. While it is difficult to find the exact new price since it depends on options, a mid-range model would cost in the ballpark of 500,000 DKK.[9] Since 150% of this price is taxes, the tax revenue per each of these is 300,000 DKK.[10]

[8] Source: statbank.dk, accessed January 3, 2017

[9] According to a brochure for the 2018 model of Mercedes C-class, there are 34 varieties with prices ranging from 400,000 to 1.6 million DKK.

[10] Our calculation of lost tax revenue is conservative, in the sense that we assume that 900,000 DKK Tesla purchasers switch to merely 500,000 DKK gasoline luxury vehicles.

	Number	Value (single)	Tax Rate	Tax(single)	Tax Total
No purchase	187	0	0	0	0
Tesla Model S	382	1,120,000	20%	186,600	71,281,200
Merc. C cl.	938	500,000	150%	300,000	281,400,000
Total	1507				**352,681,200**

Table 5: Lost Tesla tax revenue from early announcement of tax change

For a summary of our estimates, see Table 5. The bottom line figure is that by announcing the tax hike on electric cars in the summer, the Danish government lost 352 million DKK (47 million Euro) of tax revenue. While this estimate is crude, it is likely in the correct order of magnitude. Not only was this lost revenue, but it can also be thought of as a transfer to the purchasers of luxury vehicles, who presumably are among the wealthiest in Danish society.

6 Conclusion

In this paper we described the market for new and used Tesla Model S vehicles just before and after a dramatic increase in the Danish registration tax on electric vehicles. We presented evidence that speculation did not account for the surge in sales. Rather it was simply consumers moving planned purchases of Teslas forward. We predict that more than a year's worth of Tesla sales were moved forward, so the media reports of the death of electric car sales in Denmark are somewhat misleading. In a crude calculation, we estimated that the losses to the Danish tax authorities by announcing the tax hike well in advance amount to hundreds of millions of Danish Kroner. Moreover these tax revenues would have been collected from the relatively wealthy who purchase luxury automobiles. Governments considering tax hikes would do well to consider the revenue losses and implicit transfers of announcing the change in advance of implementing it.

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