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

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July 11, 2018

Abstract

We study the consumer response and tax revenue implications of the early announcement of a durable good tax. In 2015, the Danish government announced a tax hike on electric vehicles several months before its implementation. There was a dramatic surge in sales of Tesla Model S vehicles just before the tax came into effect, and a dramatic ebb in the months following. We find that the government lost 169 million DKK (23 million Euro) in tax revenue on luxury vehicles by announcing the tax change before its implementation. We further find that speculation played at most a limited role in the Tesla sales surge. In total, final consumers of Teslas gained from the rollout of the law change by avoiding the new tax.

1 Introduction

In this paper we study the consumer response and tax revenue implications of the timing of announcements of tax changes on durable goods. Our approach is to analyze a particular tax hike episode in Denmark. In October of 2015, the Danish government announced

*We wish to thank participants in seminars at Copenhagen Business School and the Danish Symposium in Applied Statistic for helpful comments. This work partially extends and revises results in Paizs' masters thesis "Taxing Electric Vehicles: Market reaction and policy lessons from Denmark".

it would begin assessing a registration tax on electric vehicles in 2016. Sales of the Tesla Model S – an expensive, fully electric luxury sedan – surged with 1248 new registrations. This surge made the Tesla Model S briefly the most sold car in Denmark. Immediately following the sales surge was a dramatic sales ebb. Only 78 Tesla Model S cars were sold in 2016.

The Danish government chose to announce the tax change well before the implementation date, allowing auto buyers ample time to purchase new vehicles ahead of the tax increase. Some of these buyers may have intended to speculate and re-sell their cars shortly after the law's implementation. The aim of this note is to determine which parties gained and lost from the structure of the tax law's implementation, with a particular focus on the long window between announcement and enactment. The big loser in our calculations is the government. By announcing the tax change in advance, the government lost tax revenues from auto sales. We estimate 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 169 million Danish Kroner. Using data we scraped from the most popular online used car marketplace in Denmark, we find little evidence of speculation in the used car market. Instead, our evidence suggests that most of the late 2015 Tesla sales were to consumers who were originally planning on buying in 2016. It is likely that final consumers of new Tesla's gained from the tax rollout and avoided the new tax by purchasing in 2015.

There is a large literature which studies the consumption response to overall tax changes and the anticipation of tax changes. Yet 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 impact 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. There are fewer studies which focus on the effect of sales taxes on consumption, but these papers find an increase in durable consumption prior to a VAT increase. 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. A number of studies have found that consumers time purchases of durable goods in order to avoid taxes[Attanasio and Weber, 2010, Cashin and Unayama, 2016, Büttner and Madzharova, 2016]. While our findings are consistent with this extant literature, we focus on a much narrower tax change – an increase in the tax on only new electric cars. We find that the anticipation of a sales tax increase has a significant effect on purchases of durables. The pre-announced tax hike on electric vehicles led to more cars on the road in the short run. Similar shifts in the timing of vehicle purchases as a response to incentives have been observed in the United States [Mian and Sufi, 2012, Hoekstra et al., 2017].[1]

2 Background

In the years leading up to 2016, the Danish registration tax for new cars was among the highest in the world. Consequently, prices paid by consumers for cars were also among the highest. Electric vehicles were exempt from the registration tax but still subject to the 25 percent VAT. Until mid-2015, it was expected that the tax break on electric vehicles would remain unchanged in 2016 [Skatteministeriet, 2015a,c].

On October 9, 2015 the government announced that all electric cars would gradually lose their tax exemption with a phase-in beginning with 20 percent of the standard registration tax from January 1, 2016, and an increase of 20 percent in each year until 2020.[2] Numerical examples on the effects on various electric cars were provided by the government, and widely referred to in the media at the time. These examples suggested that for the Tesla S P85D the price paid by consumers would rise by 81 percent in 2016 to 1,522,000 DKK, to reach 1,802,000 DKK (241,000 Euro) by 2020.[3]

[1]This finding also 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].

[2]Tax rules were later amended in 2017 after sales of electric vehicles collapsed in 2016.

[3]On the 17th of December, the Directorate-General for Competition decided that the proposed tax change on electric vehicles was an anti-competitive subsidy to small vehicles in violation of EU rules,

While we focus on changes in the registration tax on electric vehicles, on November 19, 2015 the Danish Government also announced, with immediate effect, that the general registration tax on non-electric cars would be lowered with the top rate reduced from 180 percent to 150 percent. We will need to take this change into account in our lost revenue calculations below.

Since we will be repeatedly calculating tax revenue, it is useful to spend a moment on how exactly registration tax and VAT is assessed on automobiles in Denmark. The calculation of the actual registration tax for a particular vehicle can be quite complicated as there are myriad rebates for safety features, fuel efficiency, and other options. These rebates do not typically scale with the value of a car, so they make up only a fraction of the taxes on the relatively expensive vehicles we consider here.[4] Thus we will ignore them below to simplify the analysis. We use the formula that the marginal registration tax is 105% of the value of the vehicle up to 82,800 DKK in 2015, and 104,300 DKK in 2016, which we call the first bracket of the before-tax retail price. Thereafter the top rate is assessed up to the full retail price of the vehicle. This top rate was 180% until 2016, and then 150% thereafter. The VAT is then assessed on top of the registration tax. The final price paid by a consumer for a non-electric car is:

$$\begin{aligned}\text{final price} = (1 + \text{VAT})\,(1.05 * \text{first bracket retail price} \\ + \text{top marg. rate} * (\text{remaining retail price}) + \text{retail price})\end{aligned} \tag{1}$$

For example, if the retail price of a non-electric car were 100,000, in 2015 a consumer would pay $(1 + 0.25)(1.05 * 82,800 + 1.8 * (100,000 - 82,800) + 100,000) = 272,375$. For electric vehicles, in 2016 the registration tax was multiplied by 0.2, resulting in the

and the Danish government made amendments the following day. According to the government's new calculations, the revised tax would lead to a 21 percent increase in the price of the Tesla S P85D to 1,051,000 DKK in 2016 and gradually increase to 1,626,000 DKK in 2020. For more government price estimates see Skatteministeriet [2015b].

[4]For inexpensive automobiles, however, these rebates can significantly reduce the value of taxes as a percentage of the final price.

formula:

$$\begin{aligned}\text{final price} = (1 + \text{VAT})\,(0.2 * (1.05 * \text{first bracket retail price} \\ + \text{top marg. rate} * (\text{remaining retail price})) + \text{retail price})\end{aligned} \tag{2}$$

3 Data

Our data contains monthly data 2004-2016 aggregated to the segment level from Statistics Denmark. For our purposes, the segment of primary importance is the "premium" segment which includes Tesla Model S, and has as representative cars the Audi A6, BMW 5 Series, and Mercedes Benz E Class. For comparison, we also consider registrations of the larger "Large" segment, which includes for instance Audi A4, BMW 3 Series, and Mercedes Benz C Class. For each segment in each month, the total number of new vehicles registered is reported along with their average price. We also have monthly data from the Danish Car Importers Association on the number of Tesla Model S cars registered each month for the period 2013-2017 (the first was registered in August 2013), and data on sales per segment in 2017.

Figure 1 presents the monthly time series of new Tesla Model S registered in Denmark around the change in tax law from 2012-2017. The solid line is Tesla registrations and the dashed line is other premium segment registrations. The dotted line is registrations in the large segment. The right side y-axis applies to the large segment vehicles, and the left side applies to the other segments. There is a swift rise in the number of Tesla registrations leading up to December 2015, and then a dramatic fall beginning in January 2016.

Registrations of non-Tesla electric vehicles, mostly small inexpensive city cars, may have reacted to the tax change as well with a substantial increase in sales in Fall 2015 relative to Fall 2014. There appears to be strong unrelated seasonality in these sales, however, with sales of non-Tesla electric vehicles peaking in September and December of 2014 and 2017 even though there were no tax changes in 2015 or 2018. Separating the standard seasonality in sales from the effect of the electric vehicle tax is difficult.

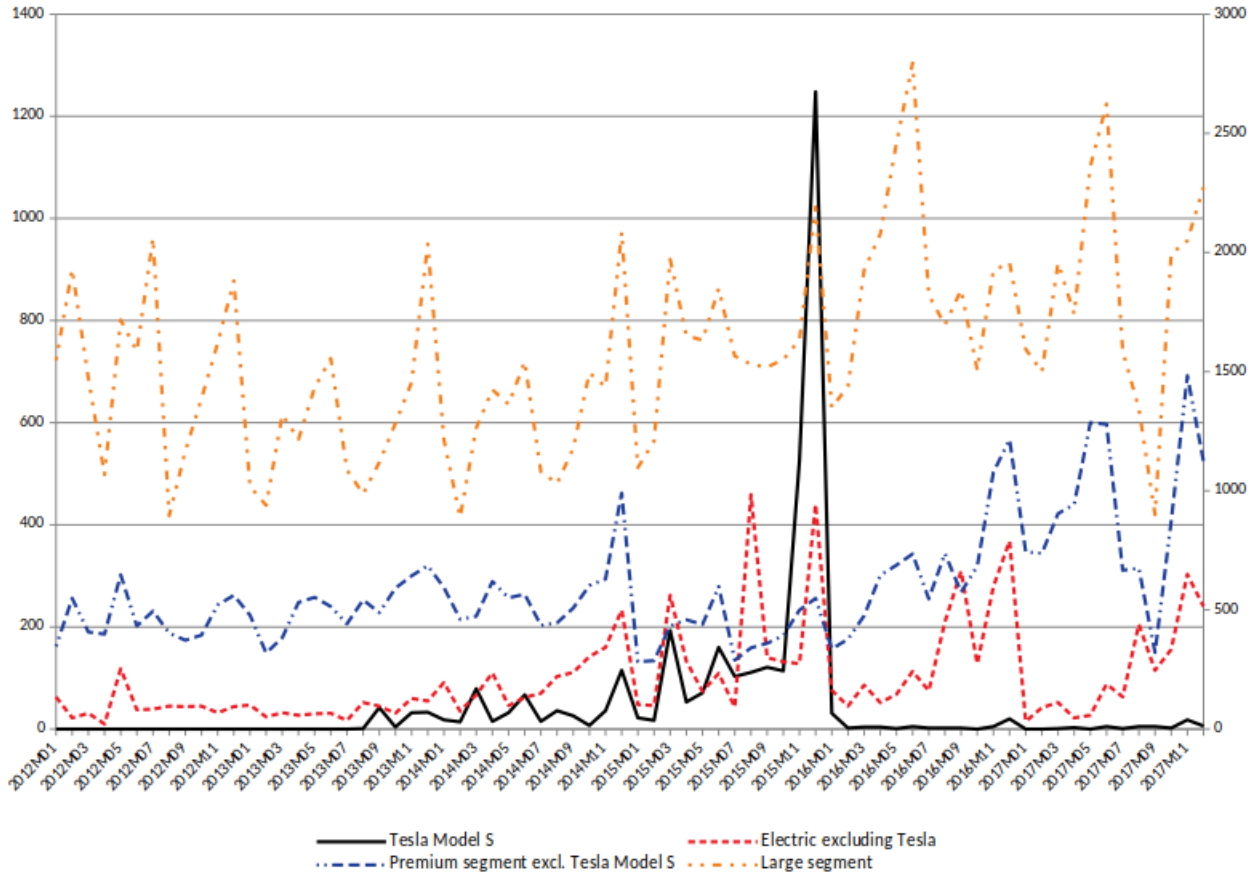

Figure 1: Registrations of new vehicles in Denmark

Moreover, due to the progressivety of the registration tax and fixed rebates for various features, overall revenues from the registration tax on small electric vehicles are relatively small. For these reasons, we focus our analysis on premium segment autos, and the Tesla Model S in particular. Our estimates can therefore be thought of as a lower bound for the overall tax effect of the preannoucement of the electric vehicle registration tax.

To further demonstrate the effect of the Danish tax announcement, Figure 2 presents Tesla Model S sales in a selection of countries. All European data is from European Alternative Fuels Observatory [2018]. We also include US data compiled from a number of sources [Cobb, a, Tesla, 2018, Cobb, b]. The bold line is Danish registrations, and the thinner lines are other countries. Other countries show a gradual increase in Telsa Model S sales over the five years from 2013 to 2017. There were no large fluctuations in other

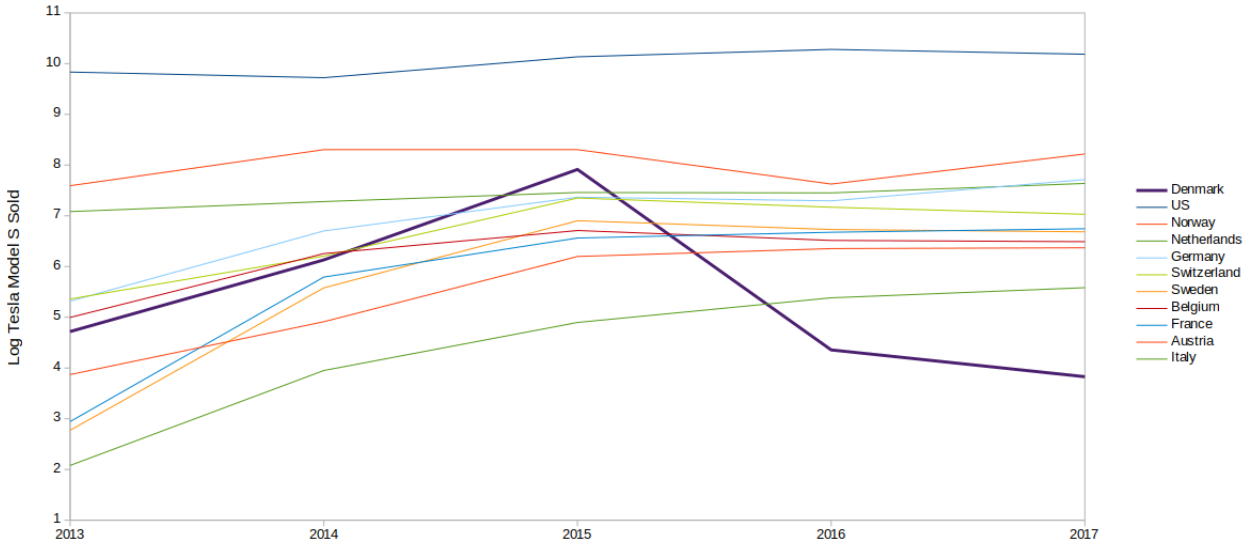

Figure 2: Tesla Model S sales by country

countries relative to trend in 2015 or 2016. Denmark, however, became the third largest Tesla market after the US and Norway in 2015, and then saw Tesla registrations collapse in 2016.

4 Analysis of Lost Tax Revenue

In order to calculate the revenue implications of the preannouncement of the 2016 tax change, we must calculate counterfactual automobile sales and tax revenue had there been a surprise announcement of the electric vehicle tax hike to compare with the observed tax revenue. We proceed as follows:

1. Project Tesla Model S sales based on trends before the tax change announcement.
2. Calculate the price increase in Tesla Model S implied by the new EV tax.
3. Calibrate own and cross-price elasticities for Tesla Model S.
4. Calculate counterfactual auto sales using projections, elasticities, and price changes.
5. Calculate tax revenue from these counterfactual auto sales, and compare to observed tax revenue.

4.1 Projecting Tesla Model S sales

We obtain a benchmark for the number of Tesla Model S cars that would have been sold had there been no tax change by predicting post-announcement sales by fitting a linear time trend. We use data from August 2013, the month in which the first Tesla Model S was registered in Denmark, to September 2015, just before the EV registration tax announcement. As is evident from Figure 1, sales volumes fluctuate widely over time. We control these fluctuations using three strategies. Results are included in Table 1 below. In column one, we include the quantity of large vehicles registered as classified by Denmark Statistics. This category of vehicles is not in direct competition with the premium segment of cars such as Tesla Model S, but may reflect overall trends in the Danish economy. In the second column, we include quarter fixed effects, and finally in the third column we include calendar month fixed effects. In all of our regressions, sales of the Tesla Model S are increasing by several units each month. Not surprisingly, we have a very good fit ($R^2 = 0.818$) when we include month dummies, since this involves 12 regressors on 25 observations. We use this final estimate when constructing our predictions as we believe that calendar month fluctuations are important, and are partly driven by firm vehicle demand.[5]

Table 2 provides the least squares predictions. Column (1) shows the actual data and column (2) presents the predictions based on trends before the tax hike was announced. Not surprisingly, the sales of 1887 Teslas in late 2015 (column (1)) far exceed the 312 predicted had there been no change in any of the taxes (column (2)). For the 2016 calendar year only 78 Teslas are sold compared to the predicted 1684. The total period sales from October of 2015 to December of 2016 are similar, at around 1900 Teslas sold. We take this as evidence that the increase in registration tax did not dramatically decrease Tesla Model S sales, at least in 2016. Instead, the law change simply shifted sales from 2016 to 2015. In column (3) of Table 2, we use the elasticities discussed below to adjust

[5]For example, sales of premium cars spike each December, the last month of the tax year when plants are often trying to spend any remainder of their budgets. Our department gets a new coffee machine in the kitchen almost every December.

	(1)	(2)	(3)
	Model S Sales	Model S Sales	Model S Sales
Monthly Trend	2.976	4.233	3.894
	(1.010)	(1.297)	(0.928)
Large vehicle sales	0.0788		
	(0.0235)		
Cal. Month Dummies	No	No	Yes
Quarter Dummies	No	Yes	No
Constant	Yes	Yes	Yes
N	25	25	25
r2	0.588	0.381	0.818

Standard errors in parentheses

Table 1: Regression of Tesla Model S registrations on a time trend

	Data	Project	General Tax Reduction
	(1)	(2)	(3)
Oct-2015	114	76	76
Nov-2015	525	104	104
Dec-2015	1248	144	132
Jan-2016	31	90	83
Feb-2016	2	86	79
Mar-2016	4	206	189
Late 2015	1887	324	312
2016 total	78	1684	1546
Period total	1965	2008	1858

Table 2: Tesla Model S registrations, projections and data

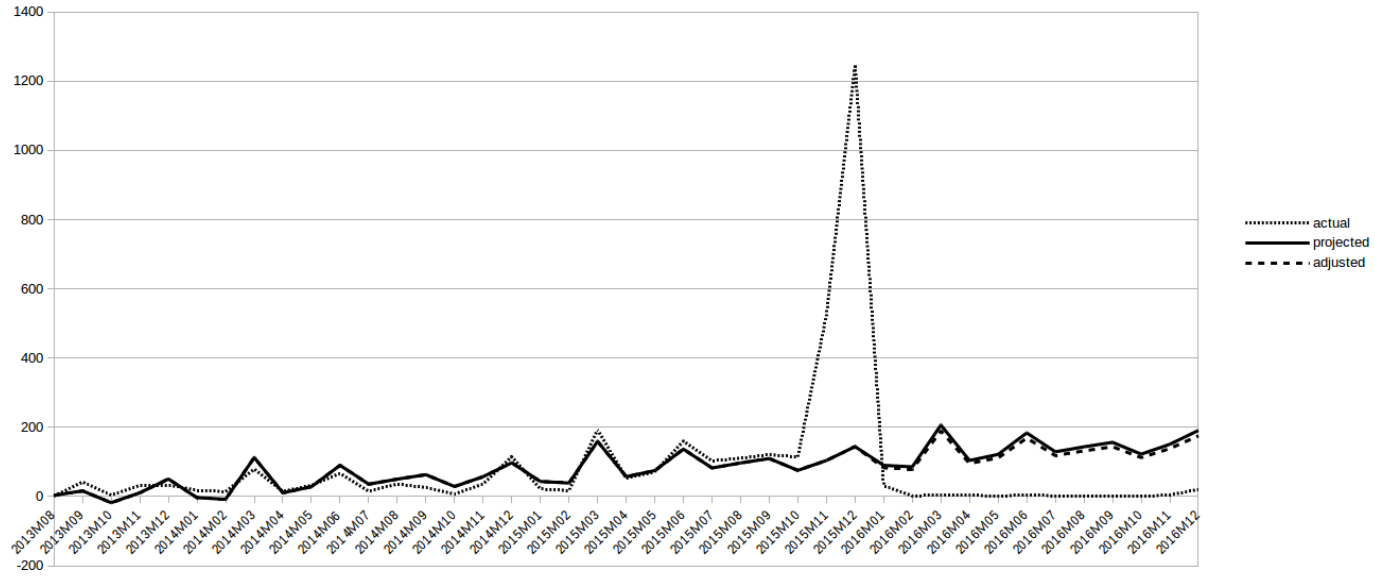

Figure 3: Tesla Model S sales

projected Tesla sales to account for the 2016 general reduction in the registration tax which was announced as a surprise at its implementation at the end of November 2015.[6] The predictions in column (3) are slightly muted relative to those in column (2).[7] Figure 3 contains a graphical representation of both the actual data on Tesla Model S sold, our least-squares no-tax-change prediction, and an adjustment to account for the overall registration tax change only.

[6]Because our data are monthly, we treat the Nov. 19th surprise drop in the registration tax as coming into effect on December 1st. Further details of how this calculation was performed will be discussed below.

[7]While it might have been forecast that the liberal government would reduce vehicle taxes, the finance law containing the overall reduction in the registration tax was not passed until November 19, 2015. Since our focus is on the electric vehicle tax, we assume that this tax change was not anticipated by the market. Our estimates will be affected if consumers who moved planned 2016 Tesla purchases to 2015 to avoid the electric vehicle tax, after learning of the reduction in registration taxes overall would have preferred to buy some other vehicle in 2016. We believe this case to be sufficiently rare that its effect on our calculations will be marginal.

	2015 Final Price	Retail Price	2016 Final Price	Final Price Change
Tesla Model S	655,380	524,304	840,260	28.2%
Non-Tesla Prem.	558,669	181,798	509,451	-8.8%
	2015 Tax Revenue		2016 Tax Revenue	
Tesla Model S	131,076		315,956	
Non-Tesla Prem.	376,871		327,653	

Table 3: Per-vehicle Price and Tax Calculations

4.2 Estimating pre-tax and post-tax prices

In order to calculate tax revenues, we must determine mean prices of both Tesla Model S and non-Tesla vehicles. In our register data, we have a mean monthly retail price for premium segment autos. Since we know the monthly market shares of Tesla and non-Tesla cars, and if we assume prices remain constant, two months of data are sufficient to back out prices. In practice, we minimize squared residuals for the period September 2014-September 2015 and find a mean price of 655,380 for Tesla and 558,669 for non-Tesla premium vehicles. We use a single year of data to reduce price fluctuations due to inflation and the business cycle. With these 2015 prices in hand, and assuming that Denmark is small enough that automobile manufacturers are not pricing to Denmark, we can calculate how taxes affected final prices in 2016. We use formulas (1) and (2) first to back out retail prices in 2015, and then to find final prices in 2016. We find that in 2016 the final price of a Tesla Model S was 840,260 DKK, 28% higher than the price in 2015. The price of a premium non-electric vehicle was 509,451 DKK, representing a 9% drop relative to 2015. Using similar formulas, we can also calculate the tax revenue per vehicle, both in 2015 and 2016. These results are summarized in Table 3.

4.3 Calibrating price elasticities

To get the predicted sales of Tesla Model S and non-Tesla premium vehicles after a surprise registration tax announcement we need the own-price elasticity of Tesla, and the cross-price elasticity of Tesla on non-Tesla. Although we are not able to estimate an own-price elasticity for Tesla, a number in the range of one to five appears reasonable and in line with other studies.[8] As a benchmark, we thus choose three for the own-price elasticity. We choose 0.93 as our benchmark cross-price elasticity as it is the number estimated in Jensen et al. [2013] for the cross-price elasticity between electric and non-electric vehicles in Denmark, and also because it roughly delivers the relationship reported in Berry et al. [2004] that the total market elasticity of a price increase is close to one.

4.4 Calculating counterfactual sales

The projection in Column (2) of Table 2 is that 1684 Teslas would have been sold in 2016 had there been no change in taxes relative to 2015. There was, however, a change in the overall registration tax which caused an 8% fall in the price of non electric vehicles. Thus, since the cross-price elasticity is 0.93, we expect that due to the change in the overall registration tax $(1 - 0.93 * 0.088) = 91.8\%$ as many Tesla Model S would have been sold as we predicted had there been no tax changes at all. Column (3) of Table 2 is simply Column (2) multiplied by 0.918 (with some rounding). We can further use the own price elasticity to predict that $1546 * (1 - 3 * 0.282) = 238$ Teslas would have been sold in 2016 after a surprise registration tax on electric vehicles was implemented. A similar calculation using the cross-price elasticity indicates that 991 additional non-Teslas would have been sold.

[8] The short time series of Tesla sales along with only small price variation over the period makes it difficult for us to estimate elasticities with our data. Berry et al. [2004] find an own-price partial elasticity of -3.94 for the 1993 American market, Jensen et al. [2013] find an own-price elasticity of -1.22 for electric vehicles overall.

	Data tax rev.	Surprise tax rev.	Diff.
Tesla Model S	272	116	-156
Non-Tesla Prem.	1,478	1,802	325
Total	1,750	1,918	**169**

Table 4: Lost revenue (millions DKK) from early announcement of tax change

4.5 Calculating counterfactual tax revenue

Using our estimates of additional sales of electric and non-electric vehicles along with our tax formulas (1) and (2), we calculate counterfactual tax revenues. Table 4 compares our calculations of actual tax revenues from *only* premium segment vehicles in the period October 2015 to December 2016 to counterfactual revenues had the registration tax been announced and implemented on January 1, 2016. Our benchmark estimate is that the lost tax revenue from preannouncing the increase in the registration tax on premium electric vehicles amounted to 168,589,213 DKK. While the total tax take from Tesla Model S is 156m DKK lower under surprise announcement, it is more than offset by an increase of 325m DKK in the total tax take from other premium segment cars. Table 5 below shows total tax revenue under different assumptions about elasticities. Intuitively if the own price elasticity is higher, tax revenue is lower since fewer Tesla Model S are sold after the tax change. If the cross-price elasticity is higher, revenue is higher since more non-Tesla premium autos are sold.

5 Discussion: Who Gained?

After the electric vehicle registration tax announcement in October 2015, Tesla Model S sales first spiked and then fell to a trickle. Compared to a counterfactual with immediate implementation, the foregone tax revenues from the unusual sales pattern of Tesla Model S and accompanying substitution effects on sales of other premium cars were around 169 million DKK. The government clearly lost, but who gained? It could have been

	Own		
Cross	-5	-3	-1
0.75	31	107	388
0.93	93	**169**	444
1	118	192	466

Table 5: Cross and Own-Price Elasticities: Premium segment tax losses relative to surprise announcement in millions (DKK)

final consumers who were planning on buying in 2016 anyway, but it could also have been speculators planning to buy low immediately before the tax hike and sell high immediately afterwards.

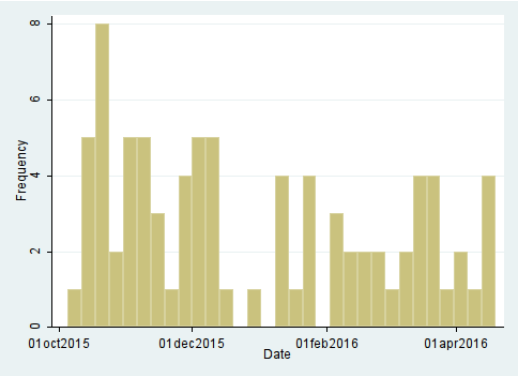

Figure 4: Listings of new Tesla Model S by week

Although there were media reports of individuals planning to arbitrage the introduction of the registration tax by buying in 2015 and selling in 2016 when prices would be higher, there is little evidence for such speculation in our data. Speculators would presumably buy and register new Teslas in 2015, and then list them for sale on bilbasen.dk in 2016. Figure 4 shows, however, that the number of bilbasen.dk listings for used Teslas with zero on the odometer (new Teslas) does not increase in our data after January 1, 2016. Moreover, in the first 17 weeks of 2016, the period for which we have scraped bilbasen.dk data, we see 37 new Teslas put up for sale, less than 3% of the number of

Teslas sold in December 2015.

Since speculation seems not to have been an important driver of the demand for Tesla Model S in late 2015, we conclude that it was rather the relatively wealthy consumers of luxury vehicles who gained from the rollout of the registration tax. Most of these consumers were first time Tesla buyers, but some owners of older Tesla models also upgraded to a newer model earlier than planned to avoid the EV registration tax. Figure 5 shows that the stock of used Tesla advertisements on bilbasen.dk increased by around 50 advertisements at the end of 2015.

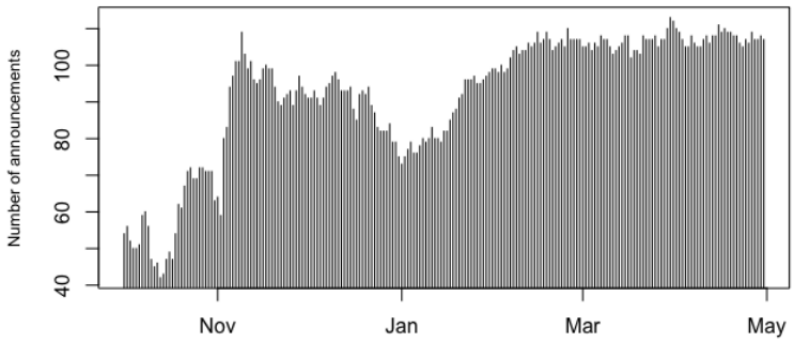

Figure 5: Daily stock of Tesla Model S ads on Bilbasen.dk

6 Conclusion

In this paper we described and analyzed the revenue effects of preannouncing a tax hike on a durable good, namely the Tesla Model S. We presented evidence that speculation did not account for the surge observed in Tesla sales. Rather it was simply consumers moving planned purchases forward. We estimated that the losses to the Danish tax authorities by announcing the tax hike well in advance are on the order of hundreds of millions of Danish Kroner. Moreover, these tax revenues would have been collected from the relatively wealthy who purchase luxury automobiles.

Other countries with high Tesla sales have also announced the end of subsidies for electric cars in advance; for example both Norway and Hong Kong announced the end of subsidies before they were implemented.[9] Hong Kong, which also has a high registration

[9]Norway ended up scrapping the proposal before it was implemented in 2018.

tax on vehicles, saw a similar surge and drop off in sales as in Denmark when they raised taxes on electric vehicles in 2017. The government there likely lost significant revenue from Tesla purchasers due to the early announcement. The bottom line is that governments must consider strategic responses when they consider the rollout of tax changes on durable goods. Otherwise they may end up both losing revenue and implicitly subsidizing purchasers of the good being taxed.

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