Behavioral Responses to Pigouvian Car Taxes: Vehicular Choice and Missing Miles

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Abstract

We study the multiple margins of behavioral response to car taxes in Finland. We do this by exploiting multiple policy reforms and a randomized control trial that varies the salience of a public disclosure program that renders car tax evasion less attractive by overstating car mileage. Preliminary results suggest that car taxes do affect the vehicle choices of individuals, in part by affecting the choice of importing new versus used cars. We also find systematic evidence of tax evasion in the form of "missing miles". The use of comparison information in the RCT reduced reported mileage. The public disclosure of mileage information affected real behavior, as it resulted in a decline in imported used cars once the tax evasion channel was shrunk by the tax enforcement measures of the customs.

Keywords: car tax, tax evasion, vehicular choice

JEL-codes: [H21, H23, H26, C93]

1 Introduction

Car taxes are part of many countries' environmental policies. In a first-best Pigouvian tax regime there would be no need to single out cars for taxation, as all uses of fuel would be taxed at a rate equal to the marginal social

damage created. Nevertheless, many countries have fuel-economy dependent car taxes, which may induce consumers to choose vehicles with better fuel economy (see Sallee 2010).

As with all taxes, agents may respond in many dimensions. For the efficiency of taxation the total response is important, but because some responses like tax evasion may entail externalities, they could incur higher welfare costs (see Saez et al. 2012). With car taxes there are many possible behavioral margins. The first is whether or not a consumer chooses to buy a car. Second, a tax may induce consumers to purchase less expensive cars than otherwise, either by choosing less options for the same car or choosing a cheaper model. Third, to the extent that car taxes depend on CO2 emissions, they may affect car choice within a price range. Fourth, to the extent that the car tax base may be manipulated, there may be evasion responses. These responses are interrelated, as the facility of evasion influences the effective tax rate on the real behavioral margins.

Finnish car tax policy imposed mostly on imports is an excellent setting in which to examine these issues. The car tax rates are, on average, imposed at a high level, possibly causing large responses on all possible behavioral margins. The car tax system has been reformed on multiple occasions providing variation in both the level of car taxes and in the fuel economy dependency. In 2003 a major car tax reform reduced the car tax rates for all cars significantly, in 2008 the tax rates were made dependent on CO2 emissions, and in 2012 the tax schedule was made more steeply related to CO2 emissions. These reforms allow us to evaluate the impact of car taxes on vehicle purchase choices, and we make use of counterfactual car consumption by using a neighboring country, Sweden, as a control group; Sweden has no car tax policy, thus it provides some insight into what kind of cars individuals would purchase in the absence of car-tax induced changes in prices.

In addition, we can distinguish the car tax evasion margin from the total response to car taxes. Although individuals and firms that by importing used cars from countries with no car taxes are required to remit the tax upon registering the car to Finland, after the 2003 reform the taxes were based on lower value than the tax on new cars. Moreover, individuals importing used

cars could evade some of the car tax by reporting that the car has higher than true mileage, lowering the apparent value of, and tax on, the car.

We study the evasion response by examining novel data that provides comparison information for the mileage of the cars measured at a later date of a car inspection. Having "missing miles" as the car ages is a clear sign of car tax evasion. We can do even better. In 2014, researchers in cooperation with the Finnish customs authority implemented an extensive randomized experiment addressed to overstating the mileage of imported used cars. The experiment is tied to the use of the comparison information and a public disclosure program of reported mileage upon import. The public disclosure of information makes potentially car tax evasion visible to the public and makes tax evasion less attractive especially to importers who anticipate selling the car at some future date.

Preliminary results suggest that car taxes do affect the vehicle choices of individuals, in part by affecting the choice of importing new versus used cars. We also find systematic evidence of tax evasion in the form of "missing miles". The use of comparison information in the RCT reduced reported mileage. The public disclosure of mileage information affected real behavior, as it resulted in a decline in imported used cars once the tax evasion channel was shrunk by the tax enforcement measures of the customs.

The manuscript proceeds by describing car taxes in Finland in section 2. Section 3 explains our empirical research desing. Section 4 describes the data and section 5 the time trends in car imports. Section 6 analyses the effect of car tax reforms on car imports in a regression framework. Section 7 shows evidence of the "missing miles" and section 8 the results of the RCT. Section 9 consludes the study.

2 Car Taxes in Finland

Because very few cars are manufactured in Finland, essentially all vehicles are imported. The Finnish tax system includes a tax levied on all vehicles imported into Finland– passenger cars, vans, buses, motorcycles, etc., whether the vehicle is new or old, and must be remitted before a vehicle's introduction

to or registration in Finland. The car tax is collected by Finnish Customs, both for vehicles imported into Finland and vehicles manufactured in Finland. In this way the car tax is applied to both new and used vehicles upon their registration in Finland. The person entered in the register as the owner of the vehicle is liable for the car tax. However, if the vehicle is imported into Finland by a business that Customs has authorized as a registered agent, the registered agent is liable for the car tax.[1]

2.1 History of car taxation and the reforms

Car taxes were discussed in the Finnish Parliament from the beginning of 1950s, and the first car tax law was passed in 1958. The initial car tax was intended to be in effect only for one year and was designed to increase tax revenue and fill a severe gap in the government budget. The car tax rate was 30% of the taxable value for the car, due when the car was imported to Finland. The law is still in effect with many changes, to this day. The Appendix gives the details of changes to car tax laws and brief summary is given below.

Concentrating on more recent changes, the car tax law passed in 1994 establishes that a car tax of almost 100% of the import value of the car (tax equals pre-tax value of the car net of a 4500 FIM) (Finlex 1482/1994). VAT of 22% were paid on the taxed value of the car. The car tax for used cars imported to Finland was fairly unfavorable in that the tax related to the value of a comparable new car with greater deductions than for a new car that depend on the age of the car. This system was particularly unfavorable for cars that had been used only a little, since these cars were not eligible for many deductions.

[1] If the tax cannot be collected from the registered agent, the person entered in the register as the vehicle's owner will be liable for the tax, unless he or she can demonstrate having paid to the registered agent or its representative an amount expected to be the tax liability.

2003 reform

Major changes were made to the car tax law in 2003, which is the first reform we study in this paper (Finlex 266/2003). The law was passed in May 2003, but the new law was applied to cars imported to Finland already from January 2003. The two major changes that applied to all cars were (1) to change the definition of the tax base of cars and (2) to reduce car tax rates. The tax base had been tax-exclusive and became tax-inclusive. Customs now collected data on the prices of cars in Finland to determine a "general retail sales price" of a car, which is the average price of a similar car in Finland. Note that the car tax base now also includes possible profit margins of retailers and transaction costs in Finland. The car tax rate applied to this taxable value was set to 28%.

An example illustrates this somewhat complicated system. Take a car that is imported to Finland with a price tag of 10,000 euros. Pre May 2003 the tax base was this 10k euros minus a deduction of 770 euros. Thus the car tax was 10,000 - 770=9,230 euros. VAT was paid on top of this at the rate of 22% so that total tax inclusive value of the car amounts to (10,000+9,239)*1.22=23,460.6 euros (assuming full tax incidence). Post May 2003, the same car would be subject to tax-inclusive definition of the tax base with a lower tax rate of 28%. We need to first add car tax to import value and then add the VAT to have an estimate for the general retail sales value of a car. Car tax of the actual car is added to that value. The all tax inclusive value of the car would then be (10000*1.28*1.22-650)*1.28=19,156. This would lead the car to be around 18% cheaper than before the reform assuming full pass-through to prices of each tax, but not taking into account potential profit margins in the general retail sales value (the tax base).

The taxation of used cars was changed drastically. As explained above, the taxable value of cars was now based on the general retail sales price of a similar (used) car in Finland, while previously it was based on the tax-exclusive value of a new car. The motivation for this change was that EU court ruled that the taxation of used cars was too heavy and thus favored new cars. This change reduced the taxation of used cars in general, and

especially for recently produced used car.

2008 reform

The next major change took effect from January 1, 2008 (Finlex 1292/2007), when the car tax schedule was altered to depend on CO2 emissions of the car. This was a major change, since prior to this reform the car tax rate was 28% for all cars. Now the car tax rate varied between 10% and 40%, depending on the CO2 emissions, with the highest tax rate for cars with CO2 emissions exceeding 360 g/km. If the CO2-emissions are not available for a car, then the total weight and motive power of the car (petrol/diesel) determine a presumptive CO2-emission level, which then defines the car tax rate.

The 2009 reform

Before April 2009 value added tax (VAT) was paid according to the taxable value of a car. From April 2009 this was abolished but the share of VAT was mechanically calculated into the car tax rate. Thus, the reform of April 2009 did not change the tax burden of new or imported old cars. This change was made due to the rulings of European Court of Justice, where it concluded that Finnish tax law was not compatible with EU laws.

The 2012 reform that leads to the present tax system

In April 2012 the government reformed the car tax law by reducing the tax rate for low-emission vehicles and increasing it for high-emission vehicles. Before the reform the car tax rates varied between 12.2% and 48.8%, and after the reform 5% and 50% depending on the amount of CO2 (g/km). The tax rate schedule imposed in 2012 is the current tax schedule.

The values for acceptable deduction were also changed in 2012 reform. The standard deduction amounts to 5% of the price plus €750, or a single sum of €1500, whichever is larger. The amount of deductions can be no more than 30% of the asking price.

From the beginning of 2015 there was also a change for migration cars. They were tax exempted up to the value of 13450 euros, and from the beginning of 2015 this exemption was abolished. According to a transit rule, those cars that were purchased before the end of 2014 could still benefit from the exemption, if they are imported to Finland before the end of 2017.

The Customs estimates the value of new and used vehicles to determine the taxation value. The Customs explains on their web page that the estimation is based on the price of comparable cars sold in Finland, and is apparently based on finding a matching vehicle based on the characteristics of the vehicle, including model, year, mileage, gear (automatic/manual), power and condition of the vehicle. Mileage is an important characteristic for used cars, since one cannot change with reasonable costs the make or model of the car, but mileage can be altered with a low cost. On possible method is to just report the mileage wrong when filing the car tax, and a more sophisticated method is to use a device that changes the odometer reading of the car. The Finnish customs also provide example cases for the general public of what they think a value of certain car could be, although these only provide approximations.

2.2 Description of tax changes

Figure 1 shows the car tax rates in different periods by CO2 emissions. Because the car tax rates did not depend on CO2 emissions prior to 2008, the car tax rate is a flat line for these years. For prior to 2003 the car tax rate is put as 48%, which is the effective rate from the post tax perspective. This is somewhat in line with the definition of taxable value definition change in 2003 and the car tax rate of 28% thereafter. The 2008 reform introduced the dependency on CO2 emissions. The 2009 reform removed the double VAT treatment from professional car dealers. The 2012 reform made the slope depending on CO2 emissions steeper.

The 2012 reform increased the taxation of an average vehicle imported to Finland measured from the distribution of all imported cars. For example, an average new imported car to Finland in 2013 had CO2 emission of 135 g/km.

For this value the car tax rate increased by approximately 2 percentage points in the reform. However, the reform also increased the spread of car tax rates. Thus, the reform reduced the car tax rates in the lower end of the emission scale. The lowest car tax rate was reduced from 12.2% to 5% and the highest rate from 48.8% to 50%. The lowest rate applies when CO2 emission value is 0 g/km and the highest rate when emission value is 360 g/km or higher. The tax rate decreased for vehicles which have emissions less than 110 g/km and increased for vehicles which have emissions more than 110 g/km.

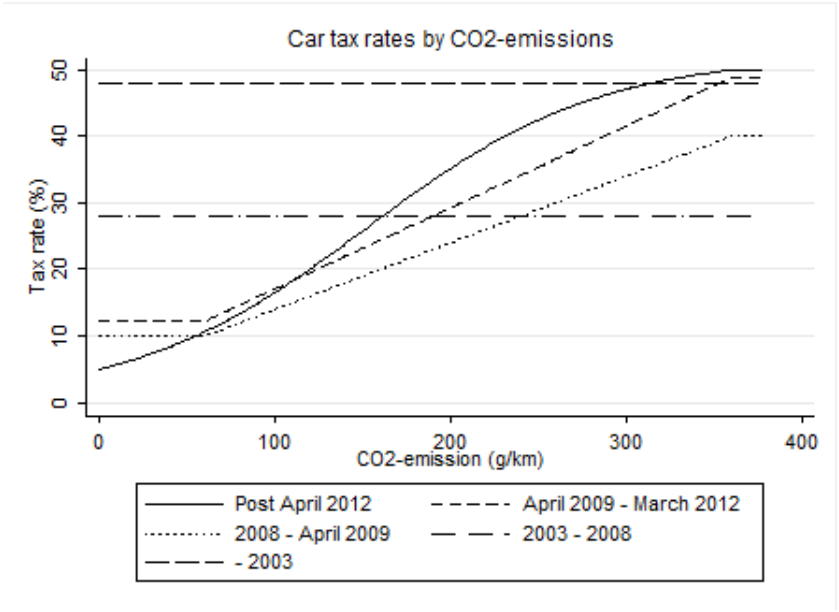

Figure 1: Car tax rates by CO2-emission before and after the reform of April 2012

Figure 2 shows the (pre-reform) distribution of cars (left y-axis) and the relative change in car tax rates (right y-axis) by CO2-emissions. It is clearly visible from the figure that, for the large mass of cars imported before the reform, the reform increased the tax rate.

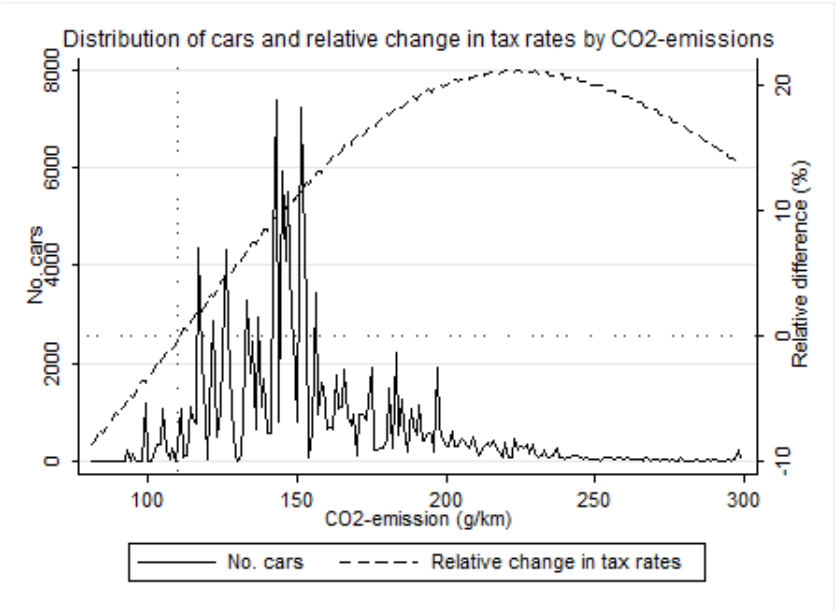

Figure 2: Distribution of imported cars (pre-reform, left y-axis) and relative difference of tax rates (before vs. after, right y-axis) by CO2-emissions

It has been described above that car taxes depend on CO2 emissions, after the 2008 reform, and even more so after the 2012 reform. The amount of car taxes also depend on taxable value of the car. Especially for used cars imported to Finland, the 2003 reform affected how this taxable value was calculated. Because car tax amount depends on two items, emissions and value, the car tax function is two-dimensional. To measure changes in incentives created by car taxes, we need to take derivatives along both dimensions. The change in value $V(m)$ of a car with emissions m affect car taxes $CT(m)$ as follows:

$$\frac{dCT(m)}{dV(m)} = \tau(m)$$

Thus the incentives to buy more expensive car is the car tax rate, holding emissions constant. Before 2008 the car tax schedule did not depend on emissions, and thus all the incentives were capture by car tax rate. After 2008 the car tax rate depends on CO2 emissions (proxied with weight if emissions are not available). Then car tax rate captures incentives to buy a car with better options that do not affect the CO2 emissions, not fully

the decision to buy a more expensive car that also has higher emissions. To calculate the incentives to buy a less polluting car, keep the value constant and consider a change in emissions m:

$$\frac{dCT(m)}{dV(m)} = \frac{dCT(m)}{Vd(m)} = d\tau$$

Thus incentives to buy a more polluting car are described by the slope of the tax schedule. This was constant prior to 2008, and positive after that. It became steeper in the 2012 reform.

3 Empirical research design

We want to identify the effect of car taxation on different aspects of car market in Finland, including the number of cars imported, the value and emissions of these cars and car tax evasion. We perform the estimations using data that cover all cars imported to Finland, and focus on changes in the car tax policy to identify the effect of car taxes on these outcomes. Challenges in identification include that the number of cars and their characteristics can fluctuate over time for reason not observed by the econometrician. We need to control for changes in outcomes that are unrelated to changes in the tax schedule, and thus the challenge is to find controls for unobserved factors. In particular, we need to control as well for possible customer preferences and changes in characteristics of cars because of technological progress. In principle, car producers might respond to changes in policy, but this is not a first-order concern here, as Finland is not a large fraction of the market to where car producers sell their products, and so it is unlikely that car makers would alter their products only because of a policy change in Finland.

We begin by estimating a regression discontinuity research design:

$$Y_{it} = \eta_m + \mu_t + \beta_1 1(after_t) + \beta_2 X_{it} + \varepsilon_{it}$$

where Y_{it} is the outcome and $1(after_t)$ takes the value of 1 after a given reform and 0 otherwise for car i at time t. Alternatively, we utilize the

actual tax rates by estimating the following kinds of specifications:

$$Y_{it} = \eta_m + \mu_t + \beta_1 ln(1 + \tau_{it}) + \beta_2 X_{it} + \varepsilon_{it}$$

where Y_{it} is the outcome and $ln(1 + \tau_{it})$ refers to the tax rate of car type i at time t.

Tax changes due to the reform are instrumented by calculating the tax change due to the law change based on the pre-reform characteristics of cars. Thus the estimation is not sensitive to small changes in the CO_2 emissions of the same model in response to the reform. The variableη_m refers to model or make specific fixed effects, thus m is a subset of i. The variable μ_t represent a flexible vector of time controls, possibly an indicator for each month. X_{it} is a vector of time-varying control variables.

We also estimate the extent the reported mileage is overreported, which is an indication of tax evasion. This is done by comparing the reported mileage with the same time or later observed cars inspection mileage. The car inspection mileage serves as the true mileage information, and discounting some sampling errors, the mileage of the cars should not systematically reduce unless for tax evasion reasons.

Finally, we estimate the effect of car importers knowing about third party information about the mileage and public disclosure of tax information of imported cars. This is done utlizing the RCT where we sent information letters to randomized receivers. The effect of RCT is estimated with differences-indifferences model where we take into account any group level differences in the baseline.

4 Data

The base data we use comes from the Finnish Customs. It includes all cars (and other vehicles) imported to Finland between 2000 and 2015. In these data we observe the key characteristics of the cars, such as make, model, type of car, weight and CO2 emissions. We also observe the information that the Customs use to calculate car taxes, such as the value of the car and

in case of used cars, the reported mileage. The Customs data also allow to see how frequently the same individuals or firms import cars to Finland. This is important information for the randomized control trial. Additionally, we observe data from the Finnish Transportation Safety Agency (FTSA) about CO_2 emissions, weight, make and model, and whether the car passed an annual car inspection or not. These data also contain mileage information from 2013 onward, which can be compared with the car tax data. The second purpose for the FTSA data are to link the Customs data to other data by using the car serial number in both FTSA and Customs data. The FTSA data also contain the registration plate numbers, which allow us to link the FTSA data to other data. Thus, using this chain of links, we can follow the same car from the day it was imported to Finland until it is removed from the FTSA registers (possibly when it is no longer in operation, or when it exits Finland for good).

From additional data sources we also observe prices and mileage of a sample of used cars sold in Finland. The sample covers 90% of car transactions in Finland between 2007 and 2014. These data are based on car sales advertisements of either firms or individuals. The most typical source of an advertisement is an Internet service for selling new and used cars, and thus is an asking price rather than a transaction price. Yet another data source contains mileage information from regular car inspections from year 2005 onward. These last data cover approximately 40% of all car inspections in Finland.

5 Time Trends in Car Imports

As background for our analysis, Figure 3 shows the number of monthly car imports in Finland. The vertical lines refer to reforms in the car tax regime in April 2003, January 2008, April 2009 and April 2012. On average more new than used cars are imported to Finland, and there is substantial seasonal variation in both categories. The effect of the 2003 reform are clearly visible for used cars, as prior to the reform virtually no cars were imported to Finland as used. After the reform the numbers pick up and stay roughly at the same

level with potentially slightly declining trend. There is also apparently a small anticipatory jump for old cars prior to the reform, which corresponds to the decision of the international court that Finland needs to change the tax system because it discriminates against used cars, which took place prior to the actual car tax reform.

Besides these overall phenomena, it seems clear that there are clear anticipatory effects after the 2003, 2008 and 2009 reforms seen by high spikes in the number of cars just before or after the reforms. The 2008 and 2012 reforms reduced the car tax rates of low emission cars and increased the car tax rates of high emission cars. On average it seems that the anticipatory effects are to postpone the car imports of new cars to after the 2008 reform and to import cars prior to 2012 reform.

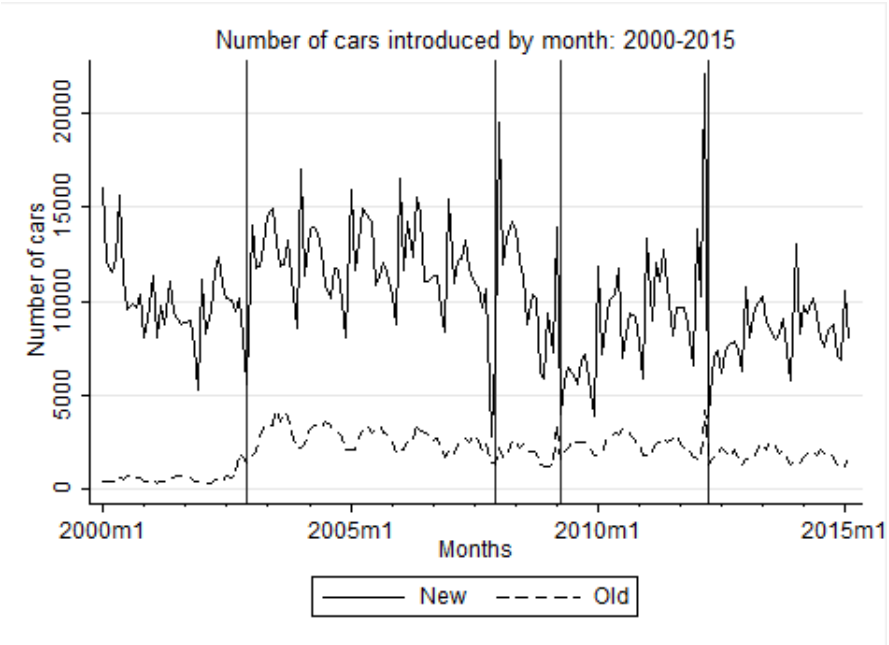

Figure 3: Number of cars by months from 2000 to 2015

Figure 4 shows the sum of aggregate tax revenue raised by car taxes for old and new cars. The tax revenue figure mirrors closely the number of cars figure. Based on these tow graphs it seems that, for example, the 2003 reform on average reduced the tax burden of cars which resulted in more cars being

imported and also more tax revenue being collected (despite of reduced tax rates). Although the Finnish government predicted that they will raise more car tax revenue after 2012 reform, the figure suggests that the car tax revenue decreased right after introducing the reform, see especially tax revenue from new cars after the reform. The government aimed to collect 140-200 million euros more tax revenue in 2012 compared to 2011. One additional point is that tax revenue seems to follow quite closely the number of cars imported (see Figure 3).

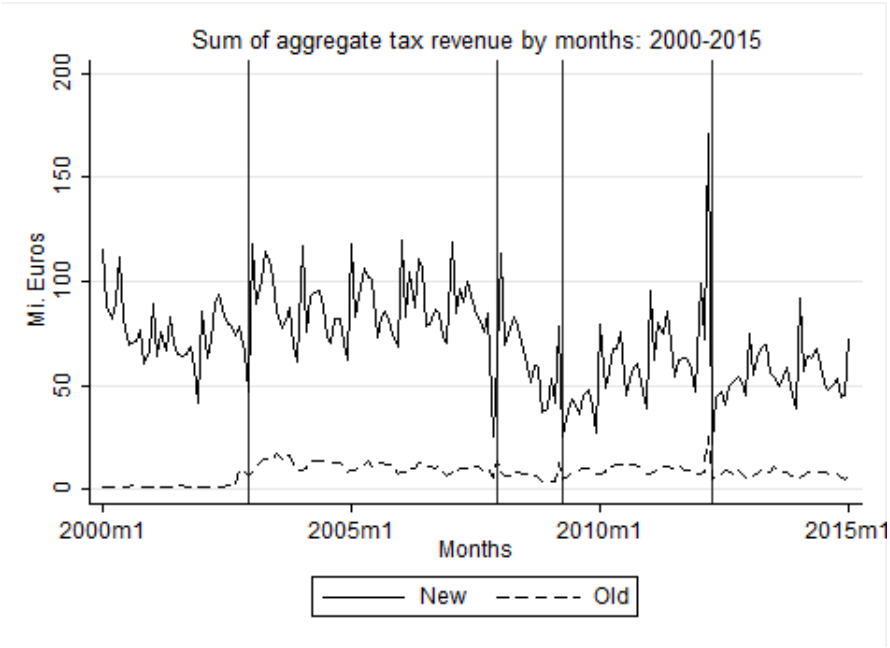

Figure 4: Sum of aggregate tax revenue by months: data from 2000 to 2015

Figure 5 shows the average weight of cars across time. The weight is of interest because it approximates the emissions of cars (related to car tax rates since the 2008 reform) and also correlates positively with the value of the car (related to the tax base). The Figure shows that used cars are on average significantly heavier than new cars. There is an increasing trend for both used and new cars that ended roughly around the time of the 2008 reform, consistent with the fact that the 2008 reform penalized higher CO2 emissions in tax rates, which are correlated positively with weight of the car.

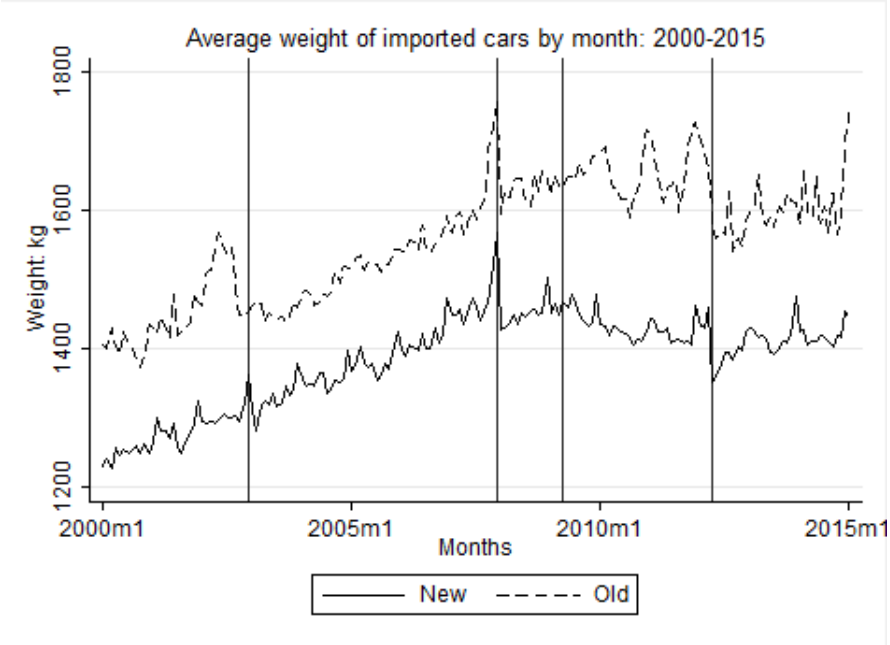

Figure 5: Average weight of cars by month in kg: data from 2000 to 2015

Figure 6 presents the number of cars imported, divided into three weight classes. Weight is coded consistently over time in the data. Since the reforms from 2008 onward treated cars in different weight classes differently, this division is meaningful. Overall it is clear that the number of light weight cars was trending down until 2008 and the number of heavy weight cars was trending up with middle weight cars showing no clear trends. The anticipatory effects of especially 2012 reform are clearly increasing with weight class. Discounting the anticipatory effects, based on the Figure it seems possible that that the 2008 and 2012 reforms decreased the number of heavy weight cars and increased the number of light weight cars.

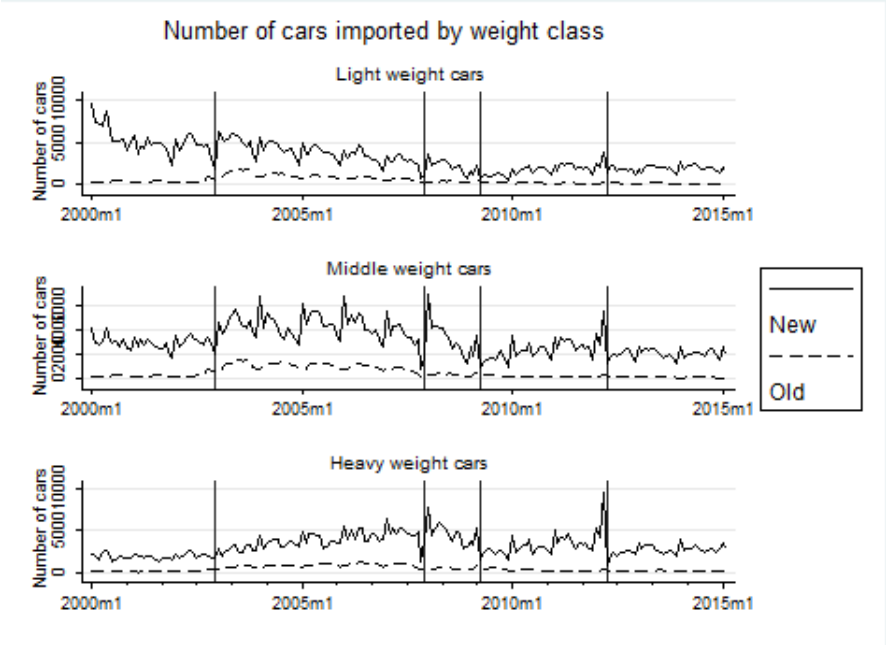

Figure 6: Number of cars divided into three weight classes by months from 2000 to 2015

Figure 7 shows the average taxable value of cars. The figure is comparable after the 2003 reform and prior to that the definition of the tax base changed. Prior to the reform the tax base was the value of the car when imported (i.e. its price abroad) and after the consumer price value in Finland. Because the latter likely includes profit margins of retailers not visible in the Customs data, and included in the taxable value after but not before, the taxable value series is not comparable over time. Just to illustrate how the series develops also prior to 2003, we calculated a comparable definition of the tax base prior to the 2003 reform by adding car taxes and value added taxes to the import values of cars.

Focusing on the 2008 reform, it seems that the increase in trend of taxable values of new cars ended then. There is also an anticipatory effect of importing more expensive cars (likely higher emission cars) just prior to the reform. After the reform there is a drop in the value of cars from which the series never fully recovers. There is a small increase in the trend after 2008 and also an anticipatory effect prior to the 2012 reform.

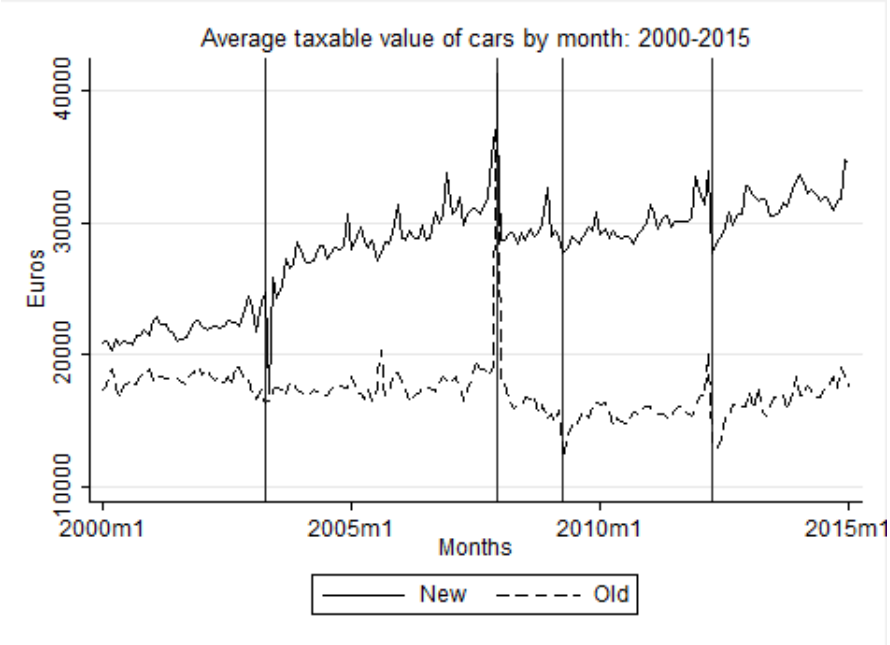

Figure 7: Average taxable value of cars by month in euros: data from 2000 to 2015

Figure 8 shows the development of price indexes of new and used cars in Finland from 2000-2014. These indexes are from a survey conducted by Statistics Finland for the purposes of calculating the consumer price index. In the price index for new cars there are clear-cut changes in prices at the time of almost every tax reform (marked with vertical dashed lines). The price index for used looks different. There seems to be a clear decreasing trend from the first tax change of 2000s almost until the beginning of 2010. In contrast to this, the value of imported used cars develops more steadily in Figure 7. The decline in prices of used cars in Finland could be explained by the presence of cheaper used cars imported as used from abroad. At least the timing of the decline in price of used cars corresponds to the 2003 reform after which the number of imported used cars picked up drastically (as seen from Figure 3). After 2010 the price index for used cars stabilizes and the trend from there on is quite flat.

The comparison between Figure and 8 is what importers report as the taxable value of the car in the former and what consumers actually pay for

the car in the latter figure. For new cars the taxable value is not a stable measure around the 2003 reform, so the two figures cannot be compared there. In 2008 reform it seem that both the taxable value and the price of new cars drops on average. In 2012 reform the evidence is more mixed, perhaps rleated to the fact that the 2008 reform was not as drastic change to the tax code as 2008 reform. For those cars imported as used the average taxable value does not change that much in 2003 reform, but Figure 3 shows that their number picks up in the 2003 reform. Since these cars are cheaper than those sold in Finland used to be, this may explain the steady decline of prices of used cars seen in Figure 8 starting from the 2003 reform.

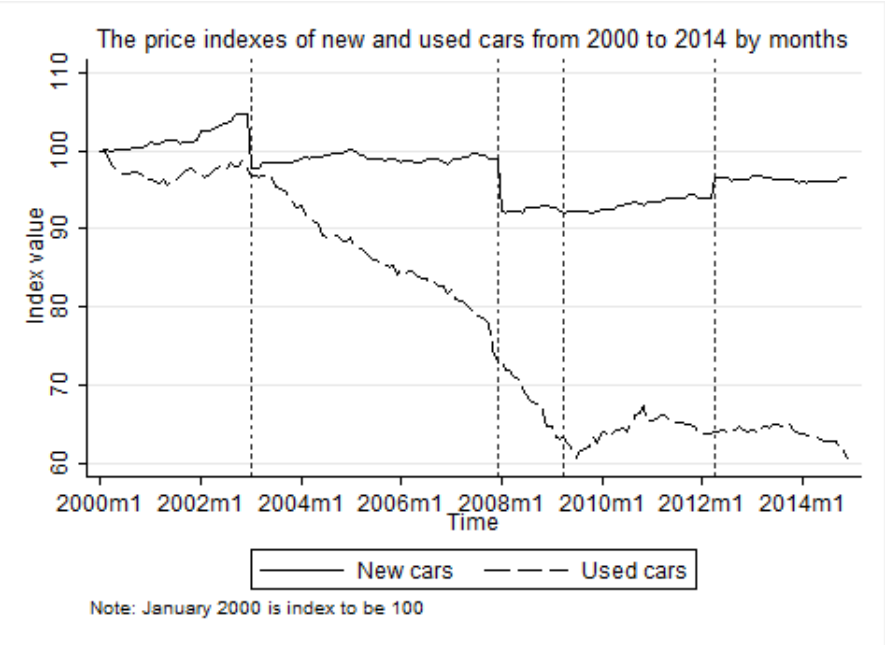

Figure 8: The price indexes of new and used cars: data from 2000 to 2014 (Source: Statistics Finland)

6 Analysis of the Effects of the Car Tax Reforms

We next show two kinds of regression results. The first set estimates the average effect of each reform on the number of cars and the taxable values

of cars. This is achieved by looking at the pre-post difference controlling for a polynomial of time trends. This generates a different RD estimate for each reform. When looking at number of cars, first a bin for make and model is specified, and then the number of cars imported in each bin is calculated by month. Taxable value is just the taxable value of cars. Note that this variable is not very informative around the 2003-reform, but is consistent over other reforms (as described above). The regressions are done separately for used and new cars.

Table 1 collects the results. The number of cars increased in the 2003 reform, decreased in the 2008 reform and increased again slightly in the reforms after that. The taxable values on average show increase in the 2008 reform for new carsa and a decrease for used cars. The latter two reform create an opposite effect, value of new cars decrease and used carsa increase.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARS	N cars	N cars	N cars	N cars	ln tax value	ln tax value	ln tax value	ln tax value
	New	New	Used	Used	New	New	Used	Used
reform2003	359.2***	398.0***	37.0***	38.0***	0.134***	0.138***	0.015**	0.007
	(3.270)	(3.287)	(1.140)	(1.161)	(0.001)	(0.001)	(0.007)	(0.007)
reform2008	-302.0***	-255.5***	-18.2***	-17.2***	0.031***	0.039***	-0.042***	-0.043***
	(4.628)	(4.658)	(1.507)	(1.525)	(0.002)	(0.002)	(0.010)	(0.010)
reform2009	-49.5***	33.6***	22.7***	29.0***	-0.025***	-0.021***	0.055***	0.039***
	(4.368)	(4.473)	(1.266)	(1.314)	(0.002)	(0.002)	(0.008)	(0.008)
reform2012	28.5***	141.0***	37.0***	46.4***	-0.017***	-0.015***	0.013	-0.012
	(6.728)	(6.847)	(2.008)	(2.055)	(0.002)	(0.002)	(0.013)	(0.013)
Constant	1,329.0***	1,368.3***	13.9***	-5.4	9.798***	9.822***	9.530***	9.570***
	(6.605)	(6.973)	(3.514)	(3.665)	(0.002)	(0.002)	(0.022)	(0.023)
Time trends	x	x	x	x	x	x	x	x
Month dummies		x		x		x		x
Obs	1,928,788	1,928,788	380,560	380,560	1,902,796	1,902,796	364,976	364,976
R-squared	0.177	0.183	0.103	0.109	0.105	0.108	0.017	0.020

Table 1: Regression discontinuity results

Table 2 shows the results interacting the RD dummies with the quartiles of weight of cars. We use weight, as we do not observe CO2 emissions for

new cars and the weight is correlated with the fuel consumption (and CO2 emissions) which determines the car tax rate from the 2008 reform onward. For used cars we do not have information of the weight from 2008 onward and thus, we use CO2 emission information directly for those to divide the sample to quartiles. The aim of these estimations is to show how the reforms affect differently those kinds of cars that probably faced a tax rate reduction than those that probably faced a tax rate increase.

The results indicate that the number of cars increased on average in the 2003 and 2012 reforms and decreased in the 2008 reform. The 2003 reform did not seem to create opposite effects by weight class, but the 2008 and 2012 reforms did. In the latter reforms more light weight cars were imported but less heavy weight cars. This is natural since the latter reforms introduced the CO2 dependency into the tax code. The value of cars seem to have been decreasing in the 2008 and 2012 reform except used cars in the 2012 reform (we do not have a coherent value series for the 2003 reform). Interestingly, the average decrease is driven by the first weight quartile and there is an increase or zero change as a net in other classes. The increase in the value of especially new cars is likely to reflect the passing through of the car tax to prices (taxable value is consumer price since 2003 reform).

We plan to do regressions comparing the Finnish and Swedish car imports (Differences-in-differences analysis) and using car tax rates as dependent variable in the near future.

7 Missing miles

Thus far the preliminary evidence suggests that car taxes generate overall behavioral effects. These include how many and what kind of cars are being imported and also importing used cars as a response to the 2003 reform. We next look into tax evasion when importing a used car as an additional behavioral margin. As explained in Section 2, after the 2003 reform the car tax for the cars imported as used were based on the estimated value of a similar car in Finland.

We analyze the extent of car tax evasion by looking at indicators for

under-compliance in car tax filing. It is difficult to alter the car tax rate by falsely reporting the characteristics of a car, since these are based on well measured technological aspects like CO2 emission or weight. Instead, the tax base, which in this case is the estimated value of the car, is easier to alter. The most straightforward method for falsely reporting the value of the car is to inflate the mileage. This can be done either by reporting too high a mileage number when filing the car tax, or by altering the reading in the odometer of a car.

We look at car tax evasion by the reported mileage because, as indicated above, that is what taxpayers are likely to do and because we have access to comparison information about true mileage. This comparison information originates from annual car inspections that are mandatory for all cars registered for use in public roads in Finland. Cars are also inspected in connection of the process when they are imported to Finland. The reported mileage occurs always earlier or at the same time with inspection. Because cars are the same age or older in the inspection, a negative difference between inspected and reported kilometers is a strong indication of tax evasion. Some sampling errors could result in random negative observations, but systematic negative difference is a clear indication of systematic car tax evasion.

One complication is that we have the inspection mileage from only a selected sample of cars from 2008 and from all inspected cars from 2013. At the same time we have car imports from 2000 onward. Thus, the first observed inspection mileage is likely to be some time later than the reported mileage. This results in many cars having a positive difference in mileage. Still the negative difference is informative about tax evasion.

Figure 9 plots the distribution of difference between first observed inspection kilometers and reported kilometers. The first observation is that there are a lot of close to zero difference indicating that the inspected mileage corresponds to reported mileage. There is also a distribution to the positive side corresponding to the fact that the first observed inspection may have taken place many years after a car has been imported to Finland. After a closer look there is also a steady distribution to the negative side, which indicates tax evasion since the reported mileage is greater than the later ob-

served mileage in the car inspection. Since the distribution is continuous, it indicates that the negative observations are not merely errors in the data, but a systematic phenomenon.

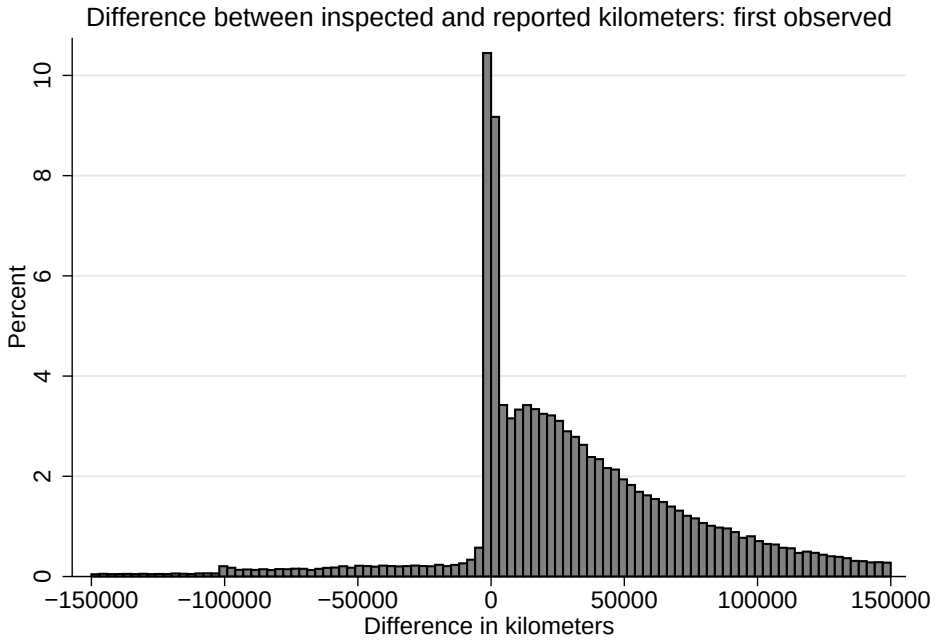

Figure 9: The difference between inspected and reported kilometers based on first observed inspection

It is possible that the lowest inspection mileage is not observed in the first inspection. This is because the first inspection occurs around the time of car tax declaration. Individuals may fear that the Customs audits the cars and checks the odometer reading of the car (based on which the kilometers are recorded in the inspection also). One method to avoid being caught from misreporting the mileage in the Customs audit is to alter the reading of the odometer. If this has been done, it would show up as similar mileage in the first inspection and the car tax declaration. It is possible that the odometer is altered back to lower mileage level later in order to make the car look more valuable when reselling it. Thus, in later inspection the mileage could be lower than in the first inspection.

To focus on the greatest possible tax evasion, we take the inspection that

has lowest observed kilometers. Figure 10 plots the negative side of this distribution. The Figure has two panels, in the left panel the lowest mileage is observed at the time of import and in the right panel at least one year later. This distinction is meaningful, since those that have lowest negative difference at the time of car tax process have likely misreported by merely putting down a wrong number to the car tax declaration form while those that have the difference later may have changed the reading of the odometer, as explained above. The distributions in the two panels look roughly similar, but notable differences exist as well. In the left side panel there is a distinctive spike at minus 100,000 kilometers and smaller spike at minus 200,000 kilometers. The spikes are not as distinct in the difference when the inspection mileage has been observed later. This distinction in round numbers supports the story that those that have the negative difference already at the inspection have just put down a wrong kilometer amount in the tax declaration form. For example, the spike at 100,000 kilometers would result from putting number one in front of the true mileage. This is tempting, since that much more mileage would significantly reduce the car tax burden. For example, a newish BMW could be estimated to cost 20,000 to 10,000 euros less with 150,000 instead of 50,000 kilometers, and multiplying that with a tax rate close to 50% gives an idea of how tempting tax evasion could be.

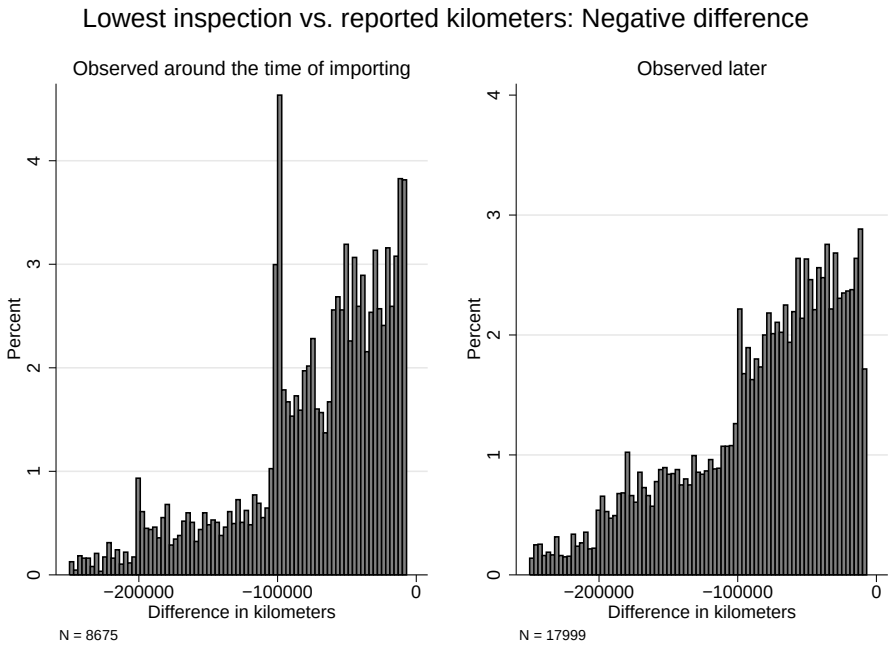

Figure 10: The difference between inspected and reported kilometers based on lowest observed inspection

Although the negative difference was a smaller part of the distribution in Figure 9, the analysis in Figure 10 clearly indicates that there are systematic car tax evasion going on by inflating the mileage in car tax decision either by filing too high mileage or by altering the odometer. Given that some tax evasion exists, we turn next to analyzing the RCT on what measures could reduce car tax evasion.

8 RCT Analysis of Enforcement Policy

In the August 2014 the Finnish customs authority initiated a randomized field experiment to improve the enforcement of the car tax. In the experiment, the Customs sent out letters providing information about new enforcement measures. There were four different letters; a baseline (control) letter and three main treatment letters.

The target population for the experiment is individuals (not firms) who

were judged to likely import a used vehicle to Finland within a year from receiving the letter. Because the population who is considering importing a vehicle is not directly observable, we targeted those who have imported a car in the recent past. The letters were sent to recipients randomized from this larger population. In the data, about 40% of individuals who bring a used car to Finland have imported a car before within a four years' time.

The treatments we planned are: 1) control, where information about car tax system and rules are explained, 2) public disclosure treatment, 3) the use of third party information and 4) joint public and third party info that combines 2) and 3). There are 5,000 letters in each group, in total 20,000 letters. The letter groups can be potentially compared with a no letter group, the baseline population where the letter groups are randomized from.

The first treatment is a control letter. The purpose of the control letter is to study how the simple fact of receiving an informational letter from the Customs affects potential car importers. This letter explains how used and imported vehicles are taxed and what happens in a case when the taxes are not correctly remitted (enforcement). There will be a randomized group that does not receive any letter.

The second treatment is public disclosure of information. The letter informs car importers that the Customs operates a web site, where anyone can search for information about vehicles imported to Finland in the past. The web site is opreated by inserting the vehicle identifying number (serial number), after which the site provides the mileage reported when the decision about the amount of car tax was made (among other information about the car). The letter specifies that "You can use the web site as a help-tool to evaluate the value of used cars in Finland. For example, if the mileage of the car is significantly larger in the car tax decision than the odometer reading later, would the value of this car be significantly higher than would be a car that has non-suspicious mileage history." The letter also mentions that the web service will likely be improved in the future. This would make the service more efficient in providing the information about used vehicles imported to Finland.

We expect that the public disclosure of information reduces the willing-

ness to over-report mileage of the car by inflating the mileage of the car when they import it and later deflating the mileage when they resell the car to reduce the tax due while preserving the higher value for the car. The chance of getting away with this is reduced under public disclosure, because the reported mileage is publicly available (and could be compared with the mileage reported when the car is in sale). In a case that the mileage is, for example, 100,000 kilometers too high, and in the future less, the history of the car looks suspicious in the eye of the public and potential buyers. This in turn would reduce the value of a car that has too high mileage in its history, but it would not reduce the value of a car that appears to have a correct mileage in its history. We do not expect that the car importers would leave too high mileage on car odometers, as this would reduce the value of the car even more than it reduces the car tax (as the car tax is less than 100% of the value of the car in Finland).

The third treatment letter indicates that the customs will check the information provided by the car importer against other administrative information about the vehicle, such as the mileage of the vehicles recorder in regular car inspection. The letter specifies that Customs will focus on mileage information. If the reported mileage in the car tax declaration is 10% lower than the comparison mileage, the Customs will perform an audit to the car tax decision. This is a probability notch design, where the notch is relative to the actual mileage. This information may or may not be available to the general public, but the most important part is that it is available for customs in enforcing the car tax. The information is provided to the Customs by the Finnish Transport Safety Agency.

The fact that one could get caught from a false mileage announcement in a car tax application also in the future increases the probability of getting caught from tax evasion. In theory this should reduce the willingness to over-report the mileage. This would be new information for the importers, as the system that the mileage is recorded in regular inspections is new.

The fourth treatment combines the third and second treatments by including into the same letter statements about the public disclosure system and the existence of the third-party information. The idea is to see if there

is a combined effect of probability of getting caught and effect of the future value of the car through the public disclosure system.

All the letters specify that the time period to which the letter applies is one year from receiving it (from August 2014 to July 2015). The effects of different letters can be disentangled by their potential differential impact on the car tax announcements. We do not expect much effect from the baseline letter, potentially a mild decrease in reported mileage throughout the whole distribution.

Evidence

We estimate the effects of the treatments on to what extent reported mileage differs from mileage in car inspection and on the number of cars imported to Finland by utilizing a differences-in-differences method.

Table 3 shows the results for difference in mileage between inspected and reported kilometers. A negative difference in the dependent variable suggests tax evasion, and thus positive coefficients in the DD variable indicate that tax evasion has been reduced due to the treatment. Column (1) gives the overall treatment effect of receiving one of the treatment letters (letters number 2, 3 or 4) against not receiving a letter. The DD coefficient indicates that the reported mileage increases by 4600 kilometers against comparison information, significant at 10% level. Column (2) compares those receiving control letter against other letters. The coefficient is still positive, but smaller and statistically insignificant. Columns (3) to (5) compare individually different treatment letters against receiving no letter. Column (4) indicates that receiving letter number 3 has the largest effect, and is statistically different from zero. Thus, the existence of third-party information in letter 3 created the strongest effect on reducing the misreported mileage. Column (6) pools letters 2 and 3 and tests their effect against receiving no letter. This coefficient is also positive and significant at 5% level.

One factor that might reduce the size of the coefficients in the regressions is that the dependent variable contains a large fraction of zeros, as visible in Figure 9. That is, the reported and observed mileage are equal and this

weights down the coefficients. We next examine the more extreme values in the mileage difference distribution by removing those observations from the outcome variable that are within 2000 kilometers from zero. Columns (7) and (8) repeat the two specifications of columns (1) and (6) without the close to zero observations. This exercise produced larger coefficients, indicating that the treatments reduced some of the higher mileage reports, and did not just move slightly those observations that were close to zero.

The result that the existence of third-party information reduces tax evasion by increasing the reported mileage seems natural. Treatment 3 targeted specifically the reported mileage and increased the probability of getting caught from misreporting the mileage. It seems taxpayers respond to this according to the standard model by decreasing tax evasion.

We now turn to the RCT analysis regarding the number of cars imported. At the moment we can only compare control letter against other treatment letters due to a data limitation. We calculate the number of cars imported before the experiment per person, from the beginning of 2012 to July 2014, and compare this to number of cars imported during the experiment, from August 2014 to August 2015. We perform individual-evel fixed effects regressions and use robust standard errors throughout.

Table 4 gives the DD results. Column (1) reports the effect of receiving one of the other letters against the control letter. The coefficient indicates that this average effect is less than one car per individual and statistically significant at 10% level. Columns (2) to (4) compare control letter against other letters individually. Letter 2 creates the largest significant effect, less than one car per person is imported after receiving the letter. This the existence of public disclosure of information seems to discourage car imports. Other letters do not produce statistically significant effects, although the point estimates remain negative. Column (5) pools letters 2 and 3 and find that these letter groups pooled also reduce on average cars per person imported by about one car.

The result the existence of public disclosure of information reduced car imports seems natural. The public disclosure of information could render the imported cars less valuable on average either because some had unclear

mileage history or because potential buyers are doubtful about imported cars. Thus, if importers think that the imported cars are now less valuable, this reduces their willingness to import cars.

	(1)	(2)	(3)	(4)	(5)
VARS	1 vs 2,3&4	1 vs 2	1 vs 3	1 vs 4	1 vs 2&3
Diff in Diff	-0.771*	-1.292**	-0.550	-0.400	-0.957**
	(0.424)	(0.596)	(0.467)	(0.472)	(0.467)
After	-0.412	-0.412	-0.412	-0.412	-0.412
	(0.359)	(0.359)	(0.359)	(0.359)	(0.359)
Constant	1.587***	1.653***	1.494***	1.494***	1.610***
	(0.027)	(0.044)	(0.032)	(0.033)	(0.033)
N	10,213	5,113	5,068	5,124	7,635
R^2	0.141	0.164	0.096	0.071	0.155
N of indiv.	8,729	4,353	4,370	4,386	6,533
Robust standard errors in parentheses					
*** p<0.01, ** p<0.05, * p<0.1					

Table 4: The effect of RCT letters on number of imported cars

It seems that both public disclosure of information and third party information had some effect on car importers. Intriguingly, letter 4 alone did not produce any significant effects, although it combines the information in treatments 2 and 3. This could be explained by the fact that combining too many things into the same one-page letter could have produced too long and confusing letter for it to have a clear effect on the receivers.

9 Conclusions

We studied the impact of car taxes on multiple behavioral margins. These margins include real responses in what kind of cars consumers purchase as well as evasion responses. We utilised number of reforms made to Finnish car tax schedule and Swedish car fleet data as a control group.

Preliminary results suggest that car taxes have large effects on the real margin in that individuals respond by importing used versus new cars to

Finland. We also found evidence of tax evasion in the form of overstating mileage information of the car in the car tax form for used cars.

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Appendix

Car taxation since 1994

The car tax law passed in 1994 establishes that a car tax of almost 100% of the pre-tax price of the car (tax equals pre-tax value of the car net of a 4500 FIM) (Finlex 1482/1994). The car tax for used cars imported to Finland was similar to the new cars with a further deduction of 0.5% for each month the car has been in use. The deduction did not include the first six months and the maximum number of deductible months was 150. A car was considered to be used if there was a "reliable" declaration according to which the car was driven at the point of entering to Finland more than 10000 kilometers and had been registered in another country at least for 6 months. A significant exemption from this was cars imported as a part of personal belongings when migrating to Finland, in which case the car was exempted from car taxes with a maximum limit of 50000 FIM. This car tax applied to all cars intended for personal use. Large trucks for professional use were either on reduced car tax or exempted. Motorcycles were under the car tax scheme as well, but for

them the tax rate depended on the liter size of the engine and the tax rate varied between 20 to 70%.

In 1997 the maximum exemption was increased to 80000 FIM and some changes were made to the tax schedule of motorcycles. In 1998 (Finlex 1160/1998) more significant changes were made to the taxation of used cars because the European Commission informed the Finnish government that the taxation of used cars was distortive compared to new cars. The law now said that the tax on a used car is the tax of a comparable new car less a deduction of 0.6% for each month the car is used from the first 100 months and deducted by 0.9% per month in use from the following 100 months. The amount of deduction was 0.4% per month in use thereafter as long as some value remained. The deduction was applied to the value remaining after the previous deduction. If the time when the car was first driven could not be clarified from a reliable source, the time was determined as the end of the year when the car was made. The law gave some discretion to the tax authorities to reduce the number of months the car had been used that were accepted in taxation if it looked like the car had not been used much. According to the law, the comparable new car is one that "mostly resembles the used car in technological aspects". The law also mentions that if the car is especially low emitting, the taxable value is reduced by 4500 FIM.

Following Finland joining the euro-zone, in 2001, the law text was changed to euros from FIM (Finlex 925/2001). The car tax was based on the pre-tax value of the car net of a deduction of 770 euros. Also, 70 euros were deducted from the tax value, if the car had a heatable rear window and a washing system for the head lights. Low emission cars had an additional deduction of 760 euros. The cap for tax exemption of migration cars was set to 13450 euros. The car tax rate had remained at almost 100% during the whole period from 1994 until 2003.

2003 reform

Major changes were made to the car tax law in 2003, which is the first reform we study in this paper (Finlex 266/2003). The law was passed in

May 2003, but the new law was applied to cars imported to Finland already from January 2003. The two major changes that applied to all cars were (1) to change the definition of the tax base of cars and (2) to reduce car tax rates radically. The tax base had been tax-exclusive and became tax-inclusive. Customs now collected data on the prices of cars in Finland to determine a "general retail sales price" of a car, which means the price the car is typically sold for and not the actual price for the car in question. The car tax rate applied to this taxable value was set to 28%.

An example illustrates this somewhat complicated system. Take a car that is imported to Finland with a price tag of 10,000 euros. Pre May 2003 the tax base was this 10k euros minus a deduction of 770 euros. Thus the car tax was 10,000 - 770=9,230 euros and the tax inclusive price of the car was 19,230 euros. VAT was paid on top of this at the rate of 22% from pre-tax price (VAT amounts to 10,000*0.22=2,200 euros). Thus the all tax inclusive price of the car was 21,430 euros (assuming full tax incidence). Post May 2003, the same car would be subject to tax-inclusive definition of tax base with lower tax rate. The applied tax rate was 28%, thus the tax-inclusive price would be 12,800 euros, if the Customs evaluated the general retail sales prices assuming full pass-through on prices. The car tax amounts to (12,800-650)*0.28=3,402. The VAT would be paid from the retail sales value: 12,800*0.22=2,816 euros. The total price tag for the car would then be 12,800+2,816=15,616 euros. Note that this calculation leans heavily on the assumption about how the Customs determined the general retail sales price for the first time in 2003.

The taxation of used cars was changed drastically. As explained above, the taxable value of cars was now based on the general retail sales price of a similar (used) car in Finland, while previously it was based on the tax-exclusive value of a new car. At the same time the deductions based on months in use were removed from the law. The motivation for this change was that EU court ruled that the taxation of used cars was too heavy and thus favored new cars. This change reduced the taxation of used cars in general, and especially for recently produced used car.

2008 reform

The next major change took effect from January 1, 2008 (Finlex 1292/2007), when the car tax schedule was altered to depend on CO2 emissions of the car. This was a major change, since prior to this reform the car tax rate was 28% for all cars. Now the car tax rate varied between 10% and 40%, depending on the CO2 emissions, with the highest tax rate for cars with CO2 emissions exceeding 360 g/km. If the CO2-emissions are not available for a car, then the total weight and motive power of the car (petrol/diesel) determine a presumptive CO2-emission level, which then defines the car tax rate.

The 2009 reform

Before April 2009 value added tax (VAT) was paid according to the taxable value of a car. From April 2009 this was abolished but the share of VAT was mechanically calculated into the car tax rate. Thus, the reform of April 2009 did not change the tax burden of new or imported old cars. This change was made due to the rulings of European Court of Justice, where it concluded that Finnish tax law was not compatible with EU laws.

The 2012 reform that leads to the present tax system

In April 2012 the government reformed the car tax law by reducing the tax rate for low-emission vehicles and increasing it for high-emission vehicles. Before the reform the car tax rates varied between 12.2% and 48.8%, and after the reform 5% and 50% depending on the amount of CO2 (g/km). The tax rate schedule imposed in 2012 is the current tax schedule.

The values for acceptable deduction were also changed in 2012 reform. The standard deduction amounts to 5% of the price plus €750, or a single sum of €1500, whichever is larger. The amount of deductions can be no more than 30% of the asking price.

From the beginning of 2015 there was also a change for migration cars. They were tax exempted up to the value of 13450 euros, and from the beginning of 2015 this exemption was abolished. According to a transit rule,

those cars that were purchased before the end of 2014 could still benefit from the exemption, if they are imported to Finland before the end of 2017.

Car taxation in the present day

The Customs estimates the value of used vehicles to determine the taxation value. The estimation procedure is not exactly known to us, or to general public. However, Customs explains in their web page that the estimation is based on the price of comparable used cars sold in Finland, and is seemingly based on finding a matching vehicle based on the characteristics of the vehicle. The characteristics are some combination of make, model, year, mileage, gear (automatic/manual), power and condition of the vehicle. Mileage is an important characteristic, since one cannot change with reasonable costs the make or model of the car, but mileage can be altered with a low cost. On possible method is to just report the mileage wrong when filing the car tax, and a more sophisticated method is to use a special rig that changes the odometer reading of the car. The Finnish customs also provide example cases for the general public of what they think a value of certain car could be, although these only gives rough guidelines.

We cannot replicate exactly the regression that the Customs uses, which more cleanly distinguish the determination of the taxable value and the tax rate. We observe all the relevant characteristics in the data we have. The variable list in the data is the same that the customs uses in car tax decisions. We also observe the actual car tax appraisals, and the value on which it is based. Thus we can see how much each characteristic of a car affected the value of a car as evaluated by the Customs in the past. Moreover, we have data on the value of used cars sold in Finland. These data allow us to replicate the estimation, although the data may not be exactly the same data that the Customs utilize.

The car tax rates applies similarly for new and used vehicles. However, often the CO2 emission information is not available for used vehicles. In these cases the car tax rate is based on the total weight and whether the vehicle has diesel or petrol engine.

Additional results

VARS	(1) N cars New	(2) N cars Used	(3) ln tax value New	(4) ln tax value Used
Reform 2003	160.0***	55.6***	0.084***	-0.340***
	(5.318)	(1.970)	(0.001)	(0.010)
By car weight quartile: 1st omitted (for used cars CO2 emissions)				
2nd * reform	430.3***	-16.2***	0.004***	0.235***
	(6.349)	(2.364)	(0.001)	(0.012)
3rd * reform	256.8***	-33.6***	0.058***	0.526***
	(6.402)	(2.501)	(0.001)	(0.013)
4th * reform	124.1***	-21.3***	0.059***	0.644***
	(6.913)	(2.638)	(0.002)	(0.014)
Reform 2008	-97.2***	-15.3***	-0.047***	-0.694***
	(10.587)	(4.065)	(0.002)	(0.022)
By car weight quartile: 1st omitted (for used cars CO2 emissions)				
2nd * reform	98.9***	2.5	0.010***	0.411***
	(13.738)	(5.534)	(0.003)	(0.029)
3rd * reform	7.1	1.2	0.050***	0.710***
	(12.585)	(5.283)	(0.003)	(0.028)
4th * reform	-606.4***	-4.6	0.086***	0.745***
	(12.448)	(5.168)	(0.003)	(0.028)
Reform 2012	354.2***	52.4***	-0.060***	0.422***
	(9.545)	(2.712)	(0.002)	(0.015)
By car weight quartile: 1st omitted (for used cars CO2 emissions)				
2nd * reform	125.0***	-4.4	0.081***	-0.505***
	(8.469)	(2.686)	(0.002)	(0.015)
3rd * reform	-86.0***	-9.8***	0.062***	-0.707***
	(8.611)	(2.915)	(0.002)	(0.016)
4th * reform	-657.9***	-20.7***	0.125***	-0.430***
	(8.513)	(3.083)	(0.002)	(0.017)
Time trends	x	x	x	x
Month dummies	x	x	x	x
Obs	1,774,538	342,997	1,757,864	331,613
R-squared	0.191	0.106	0.617	0.118

Table 2: Regression discontinuity results

VARS	(1) Nolet vs let	(2) Cont vs let	(3) Nolet vs 2	(4) Nolet vs 3	(5) Nolet vs 4	(6) Nolet vs 2,3	(7) Nolet vs let	(8) Nolet vs 2,3
Diff in Diff	4,591.5*	1,565.6	4,220.4	7,403.6**	2,065.1	5,791.2**	16,457.1*	20,660.3**
	(2,720.9)	(2,391.9)	(3,068.2)	(3,355.0)	(3,337.3)	(2,840.5)	(9,787.6)	(10,078.2)
Treat	-306.0	-549.3	-1,830.4**	-154.9	1,091.1	-1,006.9	-1,316.3	-3,204.4
	(626.7)	(858.5)	(933.5)	(924.6)	(827.3)	(724.8)	(2,004.4)	(2,267.3)
After	-2,116.7	909.2	-2,116.7	-2,116.7	-2,116.7	-2,116.7	-8,953.3	-8,953.3
	(2,407.9)	(2,028.7)	(2,408.1)	(2,408.1)	(2,408.1)	(2,408)	(8,549.4)	(8,550.5)
Constant	-4,143.6***	-3,900.3***	-4,143.6***	-4,143.6***	-4,143.6***	-13,258.0***	-4,143.6***	-13,258.0***
	(431.1)	(728.1)	(431.1)	(431.1)	(431.1)	(1,368.5)	(431.1)	(1,368.6)
N	13,771	10,639	8,497	8,408	8,416	4,110	11,130	3,383
R^2	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.003

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: The effect of RCT on missing mileage

VARS	(1) N cars New	(2) N cars New	(3) N cars Used	(4) N cars Used	(5) ln tax value New	(6) ln tax value New	(7) ln tax value Used	(8) ln tax value Used
reform 2003	116.9***	160.0***	51.7***	55.6***	0.083***	0.084***	-0.325***	-0.340***
	(5.316)	(5.318)	(1.955)	(1.970)	(0.001)	(0.001)	(0.010)	(0.010)
By car weight quartile: 1st omitted								
2nd * reform	432.4***	430.3***	-15.4***	-16.2***	0.004***	0.004***	0.231***	0.235***
	(6.373)	(6.349)	(2.371)	(2.364)	(0.001)	(0.001)	(0.012)	(0.012)
3rd * reform	261.9***	256.8***	-32.7***	-33.6***	0.059***	0.058***	0.522***	0.526***
	(6.425)	(6.402)	(2.508)	(2.501)	(0.001)	(0.001)	(0.013)	(0.013)
4th * reform	132.7***	124.1***	-19.4***	-21.3***	0.058***	0.059***	0.635***	0.644***
	(6.938)	(6.913)	(2.645)	(2.638)	(0.002)	(0.002)	(0.014)	(0.014)
reform 2008	-142.3***	-97.2***	-21.9***	-15.3***	-0.050***	-0.047***	-0.681***	-0.694***
	(10.602)	(10.587)	(4.062)	(4.065)	(0.002)	(0.002)	(0.022)	(0.022)
By car weight quartile: 1st omitted (for used cars CO2 emissions)								
2nd * reform	98.9***	98.9***	1.7	2.5	0.011***	0.010***	0.410***	0.411***
	(13.789)	(13.738)	(5.550)	(5.534)	(0.003)	(0.003)	(0.029)	(0.029)
3rd * reform	13.3	7.1	2.2	1.2	0.050***	0.050***	0.706***	0.710***
	(12.632)	(12.585)	(5.299)	(5.283)	(0.003)	(0.003)	(0.028)	(0.028)
4th * reform	-608.6***	-606.4***	-1.2	-4.6	0.086***	0.086***	0.738***	0.745***
	(12.495)	(12.448)	(5.183)	(5.168)	(0.003)	(0.003)	(0.028)	(0.028)
reform 2009	155.9***	242.9***	22.1***	31.7***	-0.036***	-0.035***	0.348***	0.326***
	(7.966)	(8.008)	(2.152)	(2.197)	(0.002)	(0.002)	(0.011)	(0.012)
By car weight quartile: 1st omitted (for used cars CO2 emissions)								
2nd * reform	119.4***	119.3***	-1.7	-2.8	-0.003	-0.003	-0.245***	-0.240***
	(9.380)	(9.345)	(2.645)	(2.637)	(0.002)	(0.002)	(0.014)	(0.014)
3rd * reform	-11.0	-10.5	-3.7	-5.1*	-0.001	-0.001	-0.320***	-0.315***
	(9.031)	(8.997)	(2.826)	(2.818)	(0.002)	(0.002)	(0.015)	(0.015)
4th * reform	-622.2***	-626.4***	-10.7***	-13.1***	0.073***	0.074***	-0.209***	-0.200***
	(9.200)	(9.167)	(3.068)	(3.060)	(0.002)	(0.002)	(0.017)	(0.016)
reform 2012	232.9***	354.2***	41.1***	52.4***	-0.061***	-0.060***	0.446***	0.422***
	(9.464)	(9.545)	(2.661)	(2.712)	(0.002)	(0.002)	(0.014)	(0.015)
By car weight quartile: 1st omitted (for used cars CO2 emissions)								
2nd * reform	124.2***	125.0***	-3.1	-4.4	0.082***	0.081***	-0.511***	-0.505***
	(8.500)	(8.469)	(2.694)	(2.686)	(0.002)	(0.002)	(0.015)	(0.015)
3rd * reform	-82.5***	-86.0***	-8.0***	-9.8***	0.062***	0.062***	-0.713***	-0.707***
	(8.643)	(8.611)	(2.924)	(2.915)	(0.002)	(0.002)	(0.016)	(0.016)
4th * reform	-651.8***	-657.9***	-17.7***	-20.7***	0.124***	0.125***	-0.441***	-0.430***
	(8.543)	(8.513)	(3.091)	(3.083)	(0.002)	(0.002)	(0.017)	(0.017)
Constant	1,244.3***	1,276.6***	4.6	-12.3***	9.643***	9.653***	9.528***	9.546***
	(7.019)	(7.421)	(3.884)	(4.033)	(0.002)	(0.002)	(0.021)	(0.021)
Time trends	x	x	x	x	x	x	x	x
Month dummies		x		x		x		x
Obs	1,774,538	1,774,538	342,997	342,997	1,757,864	1,757,864	331,613	331,613
R-squared	0.185	0.191	0.100	0.106	0.616	0.617	0.116	0.118

Table 5: Regression discontinuity results