Tax incidence in the fuel market: Evidence from station-level data

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Abstract

Most European countries tax road traffic fuels heavily, for both fiscal and environmental reasons. Surprisingly little empirical work has addressed the extent to fuel taxes are passed to consumer prices, and the empirical work has focused on US data. To the extent that the elasticity of demand changes with fuel prices, income levels and substitution possibilities through public transportation, empirical work from other countries is needed to complement the empirical knowledge on pass-through rates in retail traffic fuel markets. This paper examines the pass-through of fuel taxes to retail prices in Finland following a substantial tax reform in 2011. We use a detailed data set of daily prices at the gas-station level. The estimated pass-through rate is approximately 70% for a large nominal tax increase. The estimated pass-through rate is somewhat smaller than what previous literature suggests for the US. Nevertheless, the results indicate that a large part of the fuel tax incidence falls on consumers and that the demand for fuels is relatively inelastic .

Keywords: Excise tax, fuels, tax-incidence
JEL codes: H22, H23, Q41, Q48

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1 Introduction

Most European countries tax traffic fuels heavily, for both fiscal and environmental reasons. In Finland, excise and value added taxes add close to one euro to the average liter of gasoline (Finnish Customs 2016). Tax incidence plays a central role in the political and environmental implications of fuel taxes: The extent to which taxes are passed on to retail prices, and factors that determine the pass-through rate, affect in part the distributional impacts of fuel taxes and the effectiveness of using carbon taxes to reduce CO2 emissions from traffic.

Tax incidence theory suggests that the rate at which a tax gets passed along to consumers in a competitive market depends on the elasticities of supply and demand. For example, if supply is perfectly elastic, theory predicts that price to consumers goes up by exactly the amount of the tax. Less than full pass-through is predicted in the case where supply is less than perfectly elastic. If market power is present, pass-through can be greater or less than 100% (Weyl and Fabinger 2013).

Surprisingly little empirical work has addressed the extent to which taxes are passed along to retail prices in practice, as noted by Poterba (1996), Doyle and Samphantharak (2008) and Marion and Muehlegger (2011). Furthermore, previous empirical work on fuel tax incidence has focused on US data. To the extent that the elasticity of demand changes with fuel prices and income levels, empirical work from other countries is needed to complement the empirical knowledge on pass-through rates in retail traffic fuel markets.

This paper examines the pass-through rate of fuel taxes to retail prices in Finland following a tax reform in 2011 that increased the excise tax on diesel by 10,55 euro cents per liter and the excise tax on gasoline by 2,34 euro cents per liter. While diesel maintained its preferential tax treatment, the reform brought the overall excise taxes on diesel and gasoline closer to each other. Effects of the tax change on retail prices are estimated using a detailed data set of daily prices at the gas-station level. We focus on the effect of the diesel tax change on diesel prices, and utilize the asymmetric changes in the diesel and gasoline taxes.

We expand the empirical literature on fuel tax incidence by providing an estimate of the pass-through rate in a market with high fuel taxes and a very large nominal tax change relative to those considered in earlier literature. We also explicitly account for shifts in fuel prices in anticipation of tax changes, shown to induce large and statistically significant increases in fuel purchases in

the month leading up to tax increases in a recent paper by Coglianese et al. (2016).

The results indicate that approximately 70% of the diesel tax increase is passed onto consumers in the form of higher prices. Our data indicate that gasoline stations have increased fuel prices already two months prior to the tax change, perhaps in response to increased fuel purchases by forward-looking consumers. Accounting for this anticipatory behavior has important implications for the estimated pass-through rates: Without accounting for anticipation by gasoline stations, our findings indicate almost full pass-through of the tax change.

Once anticipatory behavior is accounted for, the estimated pass-through rate falls down to 70%, which is somewhat lower than the pass-through rates estimated by Doyle and Samphanthrarak (2008) and Marion and Muehlegger (2011) on US data. One possible explanation for this difference is that demand for traffic fuels may be more elastic in Europe than what empirical literature has indicated for the US. The highly taxed fuel prices in Finland are approximately four fold relative to US prices, and the availability of public transportation provides substitution possibilities.

This paper proceeds as follows: Section 2 describes the taxes levied on road traffic in Finland and the fuel tax reform of 2011, and reviews previous literature on fuel tax incidence. Section 3 describes the data, offers graphical evidence and methods. Section 4 offers the overall results, and Section 5 concludes the study.

2 Background and related literature

2.1 Background

Motoring is taxed in several ways in Finland. New vehicles and imported used vehicles are subject to a vehicle first registration tax (car tax), and all vehicles which are to be used in traffic must pay an annual vehicle tax. Fuels are subject to an excise tax and a value added tax. The excise taxes are defined as euro cents per liter, and the tax level varies across products.[1] The value-added tax is also paid on fuel tax. Altogether the different taxes on motoring contributed approximately 9% of the total tax revenue in Finland in 2014.

[1] Table 4 in the Appendix collects the excise tax levels in 2012 for different fuel products. The table also contains the tax levels for different products that are included in road traffic fuels.

An energy tax reform took place in 2011 that broadened the tax base to include the CO2 emissions from fuel combustion. Starting January 1, 2012, fuel excise taxes have been computed based on the energy density and CO2 emissions of each fuel.[2] The excise taxes per liter of diesel and gasoline differ, but the tax reform in 2011 brought them closer to each other. The excise tax on diesel was increased by 10.55 euro cents per liter and the excise tax on gasoline by 2.34 euro cents per liter on January 1, 2012. Altogether the excise tax then was 46.95 euro cents per liter for diesel and 65.04 euro cents per liter for gasoline.[3]

Figure 1 shows the total taxes (excise and value added) on diesel and gasoline for years 2010 through 2014, with the tax change date January 1, 2012, normalized as month 0. Another tax increase took place on January 1, 2014, amounting to 2.7 euro cents per liter for diesel and 2.25 euro cents per liter for gasoline. The tax levels in Figure 1 have been weighted by the quantities of different fuel blends as taxed by the Finnish Customs each month. Both diesel and gasoline are sold in blends that contain additives and bio-components, which are taxed differently from pure diesel oil or motor gasoline (Table 4 in the Appendix). We use the weighting in order to describe more precisely the actual level of fuel taxes per liter that consumers are facing. This weighting applies to all fuel tax levels in the subsequent analysis. Figure 1 shows that the tax on diesel increased more than on gasoline and that the difference in taxes per liter between gasoline and diesel decreased considerably. However, there is still a notable gap in the taxes on the two fuel types.

Finally, the supply chain consists of refinery and imports of gasoline and diesel fuel, terminal storage, and retail delivery. Approximately 63% of petroleum products sold to Finnish consumers were refined in Finland in 2014 (Petroleum and Biofuels Association Finland). In terms of tax collection, the value added tax is remitted to the state by the retailer, while the excise tax is remitted by the wholesale terminal. The price posted by gasoline stations includes any taxes.

[2]The tax reform was originally planned to be fully in force from the beginning of 2011 but the government decided to postpone it by a year. Increases in fuel taxes were part of a larger energy taxation reform that was otherwise introduced in 2011.

[3]The excise taxes consisted of an energy content tax of 30.7 euro cents per liter for diesel and 50.36 euro cents per liters for gasoline, and a carbon dioxin tax of 15.9 euro cents per liter for diesel and 14 euro cents per liter for gasoline. In addition to the the energy content and carbon taxes, both fuels are subject to a small supply security tax, 0.35 euro cents per liter for diesel and 0.68 euro cents per liter for gasoline in 2012.

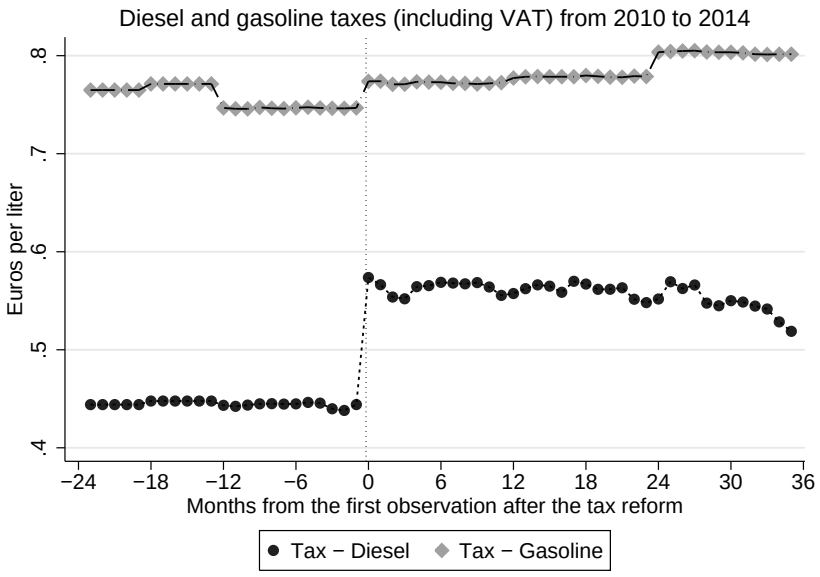

Figure 1: Diesel and gasoline fuel taxes over time from January 2010 (month -24) to December 2014 (month 35)

2.2 Related literature

Our paper contributes to the literature on fuel tax pass-through and the broader literature on tax incidence. To our knowledge ours is the first study to consider fuel tax incidence in Europe, where gasoline and diesel are taxed heavily relative to the US. Most previous work on fuel taxation has employed monthly panels of state-level prices for the US. Chouinard and Perloff (2004, 2007), Alm et al. (2009) and Marion and Muehlegger (2011) use state-level variation in prices and taxes to study the pass-through rate of gasoline taxes. Chouinard and Perloff (2004, 2007) find that differences in taxes and market power have a substantial effect on geographic price differentials. In terms of the pass-through rates, they find that 50% of the US federal excise tax is passed on to consumers, 75 % of the state ad valorem taxes are passed on to consumers, and nearly 100% of the state excise taxes are passed on to consumers. Alm et al. (2009) find that excise taxes are fully passed onto the consumers within the first month of the tax change. They also compared rural and urban states, and found that all of the excise taxes were passed on to consumers in urban states while pass-through was lower in rural states. Marion and Muehlegger (2011) analyze how

factors constraining the US gasoline and diesel supply chains – gasoline content regulations, refinery capacity constraints, inventory constraints, and variation in demand of diesel for heating – affect the incidence of diesel and gasoline taxes. They find that in periods when the supply chain is constrained, for reasons unrelated to demand, the pass-through rate of fuel taxes declines. Otherwise, their results suggest at least full, and potentially more than full pass-through of federal and state diesel and gasoline taxes, although the null hypothesis of merely full pass-through could not be rejected.

Doyle and Samphantharak (2008) use gasoline station level data for the states of Illinois and Indiana. They estimate pass-through rates for both tax decreases and tax increases, and study whether the pass-through rate varies across markets described by their distance to the state border and their levels of brand concentration. They find that about 70 % of a tax suspension is passed through to consumers, while the pass-through rates are 80-100 % for tax reinstatement. Furthermore, they find that brands earn a premium, and some evidence that greater concentration and greater distance to the state border are associated with higher pass-through.

Our paper is also related to a recent paper by Coglianese et al. (2016) on anticipatory behavior by gasoline buyers before tax increases. Coglianese et al. provide evidence that large elasticity estimates found in literature instrumenting gasoline prices using gasoline taxes may be an artifact of not having accounted for shifts in gasoline purchases in anticipation of gasoline tax changes. Our data indicate increases in diesel and gasoline prices already in the months preceding the tax increases, and we account for anticipatory behavior by several alternative specifications excluding months just before- and after the tax change.

2.3 Analytical framework

We consider a quantity tax of t per liter of fuel, which is paid by the supplier. Consumers' aggregate demand is given by $Q^D = D(p, X)$, where p denotes the tax-inclusive price of gasoline and X represents exogenous demand shifters. The marginal cost function is $MC(q, t, W)$, where t is the tax parameter and W represents cost shifters, such as the wholesale price and transport from wholesale terminals. If firms behave competitively, they produce to the point where price is equal to the marginal cost. The market-clearing price will be influenced by the tax rate and supply and demand shifters. If markets are not perfectly competitive, the price will be influenced by factors that affect firms' marginal cost

and marginal revenue. In that case, we have $p=f(t,X,W,Z)$, where Z represent variables that describe the market power of the firms.

In a perfectly competitive market, theory suggests that the fraction of tax that is passed on to consumers will be given by

$$\frac{dp}{dt} = \frac{\eta}{\eta - \varepsilon}$$

where η and ε are the elasticities of supply and demand. That is, the rate of pass-through increases with the elasticity of supply and decreases with the elasticity of demand, and will be less than or equal to 100%.

There is a large literature on the short run price elasticity of gasoline demand. Literature summarized in Hughes et al. (2008) suggests that the short-run elasticity is on the order of -0.03 to -0.08, which would imply nearly full shifting of a tax unless supply is also highly inelastic. However, most of the literature is based on US data and the results may not be applicable to a setting where fuel taxes are significantly higher – according to the OECD, the average member country taxes gasoline at a rate of approximately $2.75 per gallon, around fifteen times the U.S. federal tax rate of 18.4 cents per gallon. The low elasticity estimates may also suffer from not correctly accounting for the endogeneity of gasoline price when estimating the demand response. Furthermore, recent literature has suggested that the tax elasticity of gasoline demand may be higher than the price elasticity (Li et al. 2014, Rivers and Schaufele 2015, Tiezzi and Verde 2014, and Dieler et al. 2015). Coglianese et al. (2016) account for anticipatory behavior in gasoline purchases prior to a tax change and find an elasticity estimate of -0.37 on US data, which is in line with other recent estimates by Bento et al. (2009), of -0.35 and Levin et al. (2015), of -0.22 to -0.30.

In less competitive markets the pass-through rate can be below or above 100% (Katz and Rosen 1985, Seade 1985, Stern 1987, Hamilton 1999). While demand and supply elasticities still affect tax incidence, it also depends on the shape of the demand and supply curves (Weyl and Fabinger 2013).

3 Data and methods

3.1 Price data

We have station-level daily prices of gasoline and diesel fuels from the beginning of 2007 until the end of 2015. These data are from two separate websites (tankkaus.com and polttoaine.net) where individuals can record observed prices of fuels in a specific gas station. Individuals can enter prices to the websites in several ways by filling an online form, sending a text message or email to the moderator of the website. The data include the prices of diesel and two gasoline types with octane ratings of 95 and 98. Also, the data contain the exact location (municipality and address), the name of the gas station including the brand name and the exact time when the prices were recorded.

A potential concern in applying these data for the purposes of this study is that some individuals could record fuel prices intentionally or unintentionally (mistakes) incorrectly. However, we can evaluate the seriousness of this issue by comparing the average monthly price levels of this microdata to the evolution of the gasoline and diesel fuel price components of the consumer price index (CPI) that are collected by Statistics Finland. The evolution of diesel prices in these two data sets are shown in Figure 5. As is evident, the CPI component and microdata on diesel prices develop very similarly over time, and moreover, the difference in average diesel prices between these data sets is less than 1 euro cent in a month. Therefore, we believe that the microdata is well suited for the purposes of this paper.

Table 1 presents the descriptive statistics of the price data in euros. The Table shows the nominal consumer prices of different fuel types and the level of fuel taxes including VAT for diesel and gasoline separately from January 2011 to December 2012. We have, on average, 700-800 station-level daily price observations within this time period. On average, diesel fuel prices are lower than gasoline prices.

	Diesel - price	Diesel - tax	Gas 95 - price	Gas - tax	Gas 98 - price
Mean	1.434	.498	1.596	.758	1.650
Median	1.399	.446	1.589	.747	1.639
SD	.106	.060	.083	.013	.080
N	319,156		294,262		237,660

Table 1: Station-level daily price data

The consumer price of fuels can be divided to three components: VAT, fuel taxes, and tax-exclusive price. Table 2 shows this division for gasoline (with octane rating of 95) and diesel using the tax values of 2015. In the Table we assume that the consumer price of gasoline is 1.50 euro per liter and diesel is 1.30 per liter. The VAT rate is 24% in Finland in 2015 and the fuel tax levels are directly from the Finnish tax law. The amount of fuel taxes and VAT can be subtracted from the consumer price, and this gives the tax-free price of different fuels. We can also exploit this division and calculate how large are the shares of taxes of the consumer prices for both fuel types. For gasoline the share of taxes from consumer price is higher, 65%, than for diesel, 58%.

2015	Gasoline (95)	Diesel
Consumer price €/l	1.50	1.30
VAT €/l	0.290	0.252
VAT-exclusive price €/l	1.210	1.048
Fuel tax €/l	0.681	0.506
Tax in total €/l	0.971	0.758
Tax-free price €/l	0.529	0.542
Share of taxes %	64.8	58.3

Table 2: Composition of fuel price: VAT, fuel tax and tax-exclusive price

Figure 2 illustrates the development of different price components around the reform of 2012 using the average monthly consumer price levels. The Figure shows the average levels of monthly consumer prices for diesel (above) and gasoline (below) from January 2010 to December 2014 such that the horizontal axis describes the months from the first observation after the tax reform (0 is for January 2012). We divide the consumer prices to different components for both types of fuels over time similarly as in Table 2. The Figure above shows clearly that the level of diesel tax increased sharply right after the tax reform. Also, it is evident that the consumer prices increased at the same time. The Figure below illustrates also a small increase in the fuel tax of gasoline in January 2012. However, this change is much smaller than that for diesel.

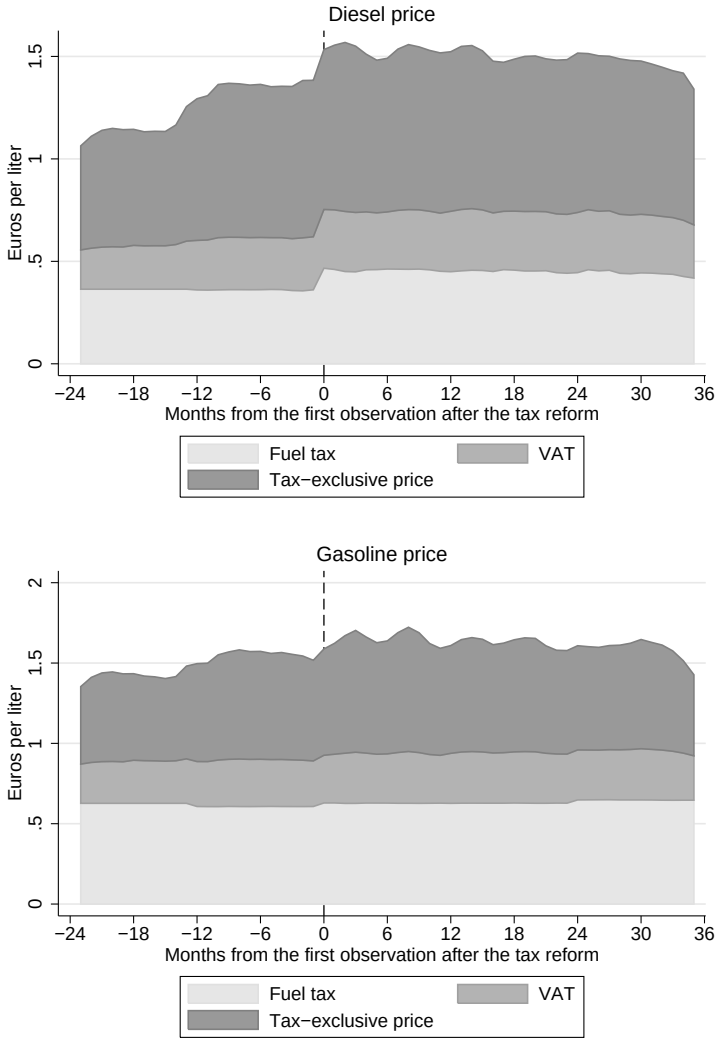

Figure 2: Composition of fuel price over time: diesel and gasoline

In Figure 3 we examine the average monthly consumer prices of diesel and gasoline over time from January 2010 to December 2014. The upper Figure shows fuel prices and the lower panel of Figure shows the indexed values (that equal to 1 in June 2011) for gasoline and diesel prices. The lower Figure also shows the index of Brent-oil. Again the horizontal axes present the months from the first observation after the tax reform in both Figures.

The Figures show that the consumer price of diesel increased sharply after the tax reform. Also, there is a small increase in the price of gasoline due to the fuel tax increase. In addition, the index of Brent-oil price (per barrel) seem to influence the index values of gasoline and diesel prices, although the changes in oil price index are much larger than those reflected to fuel prices.

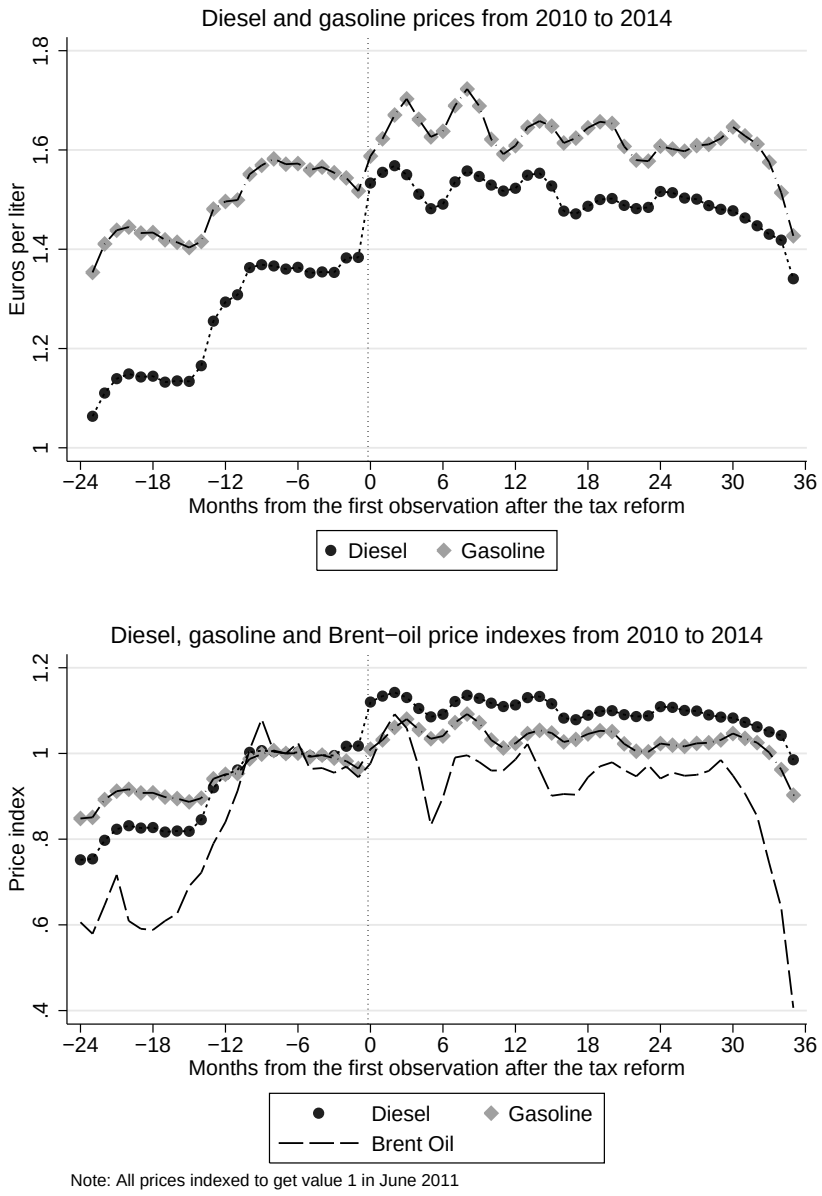

Figure 3: Development of diesel and gasoline (95) prices (above), and index values of them and Brent-oil price index (below) from 2010 to 2014

In Figure 4 we focus more closely to the development of monthly average

prices right before and after the tax reform of 2012. This Figure shows the index values for gasoline and diesel consumer prices and the index values of taxes for these fuel types. All values are indexed to 1 in June 2011 and horizontal axis is zero at the time of the reform. This Figure shows that the index values of diesel and gasoline prices develop very similarly before the reform. The index of diesel prices increased substantially right after the reform and the change in the average diesel price index appear to be similar in size with the change in the diesel tax index. Also, it seems that the gasoline price index increased slightly after 2.3 euro cent increase in gasoline taxes. This Figure gives us evidence that the tax reform increased diesel prices substantially. It also suggest a relatively high pass-through rate to diesel prices. However, there might be other factors that affect the development of fuel prices in this period such as oil price development that was evident from Figure 3. Therefore, we need to take carefully into account these other factors before making conclusions of how large was the overall pass-through. In the following sections we aim to estimate the pass-through to fuel prices in a more detailed manner.

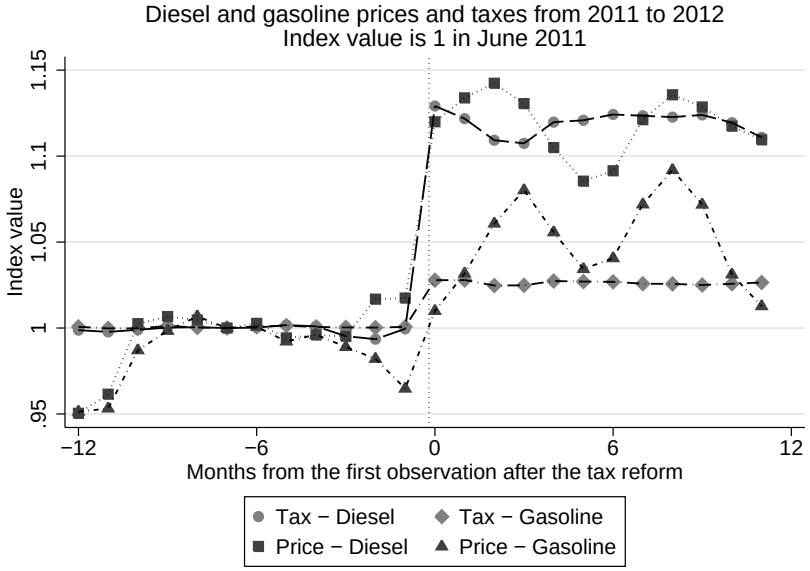

Figure 4: Index values for consumer prices and fuel taxes (including VAT) from January 2011 to December 2012

3.2 Methods

This section describes the methods. We use a natural experimental method to examine the average effect of the diesel tax reform on diesel prices. In more detail, we apply a standard difference-in-difference (DD) strategy by comparing gasoline prices to diesel prices before and after the reform of 2012 to estimate the effect of the diesel taxes on the prices of diesel.

We estimate the following equation:

$$\begin{aligned} Price_{st} &= \alpha_0 + \alpha_1 1(Diesel)_s + \alpha_2 1(Post)_t + \alpha_3 1(Diesel)_s * (Post)_t \\ &\quad + \alpha_4 Brent - Oil_t + \alpha_5 X + e_{st} \end{aligned} \tag{1}$$

where the dependent variable *Price* represents the logarithmic fuel price at gas station s at day t, *1(Diesel)* is an indicator variable with the value one for diesel and zero for gasoline, *1(Post)* is also an indicator variable with the value one for post-2012 period and zero otherwise, and *1(Diesel*Post)* represents the interaction variable of these two above mentioned variables. The coefficient of this interaction term identifies the effect of the diesel tax reform on diesel prices and thus, α_3 represents the average proportional change in diesel prices as a result of the reform. *Brent-oil* is the daily price of Brent-oil per baller, and X contains a vector of station-level control variables and ε is the i.i.d. error term.

The main assumption of the method is the parallel time trends. In other words our identification requires that the difference between fuel prices, gasoline and diesel prices, would have evolved similarly in the absence of the reform. This means that diesel and gasoline prices should have developed similarly before the reform. A potential concern is that the prices of diesel and gasoline behave differently in the pre-reform period.

A further concern might the endogeneity of the reform. This could be a problem in our setting, for example, in the case if the government aimed to affect the demand of fuels by changing the tax rates. However, this was not the purpose of the substantial tax increase for diesel in Finland. The aim was to narrow the gap in excise taxes between different types of fuels used in the road traffic.

To offer empirical evidence for the main assumption, Figure 4 shows that the development in diesel and gasoline price indexes are very similar one year before the reform. However, there seems to be an increase in the price of diesel already two months before the reform. This could be a consequence of the fact

that gas-stations have anticipated the reform by increasing the price of diesel systematically just before the turn of the year.[4] Another possible explanation is that this behavior is related to the climate conditions in Finland. In every October/November gas-stations start to distribute a different type of diesel that is more suitable to cold weather conditions. This is because normal diesel fuel is prone to gelling in low temperatures and it need to be enhanced to remain its performance in cold weather conditions. This type of diesel is also commonly more expensive to produce and thus, also has a higher price, on average.

Whatever is the reason for the higher diesel prices just before the reform, we take this issue into account in our empirical estimations with different ways. We first perform robustness checks by excluding the 3-month period right before and after the reform to avoid the potential anticipation effects. In addition, in our preferred spesification we introduce a 'winter' indicator to control for the diesel quality change during the period from October to March every year.

Finally, a well-known concern in this type of DD setting relates to the calculation of standard errors for the estimates. This is due to the fact that the error term (ε_{st}) might be correlated within groups (see e.g. Bertrand et al. 2004 and Cameron et al. (2008)) and thus, the heterogeneity robust standard errors would offer bias inferences. In order to take this issue into account, we employ the block bootstrap method with brand clusters (e.g. Shell, Teboil, ABC, etc.)).

4 Results

A clear response to the diesel tax reform was already visible in Figure 4 above. However, in the subsequent analysis we estimate the effect of the diesel tax reform on diesel prices more precisely, and offer the pass-through rate of diesel-tax change.

Table 3 collects the results. We estimate all regressions using the OLS and DD-strategy presented in equation 1. Column (1) shows first the levels and changes in the fuel taxes for gasoline and diesel. The dependent variable is the level of fuel taxes. The interpretation of the coefficients is as follows: *Constant*

[4] Figure 6 in Appendix shows a different kind of anticipation to the diesel tax reform, as it presents a clear spike in the taxable amount of diesel just before the diesel tax increase in December 2011. This suggests that the supply side clearly anticipated the diesel tax reform by taking advantage of the lower tax levels just before the reform. This could be a consequence of two different reasons: First, the suppliers of fuels transformed untaxed storage to taxed storage and, second, the suppliers increased the imports of diesel fuel sharply, or a combination of both of these types of anticipation channels. Nevertheless, it is evident that the amount of taxed diesel fuel increased substantially only one month before the diesel tax reform.

represents the level of fuel taxes in the pre-reform period for gasoline (75 c/l), *Diesel* shows how much the level diesel fuel tax differ from the gasoline tax before the reform (-30.6 c/l), *After* depicts the change in gasoline tax after the reform (2.6 c/l) and lastly, *DD* shows how much the level of diesel tax changed relative to the level of gasoline tax after the reform (9.8 c/l). Therefore, the *DD* coefficient shows how large would be the implied full pass-through to diesel prices after the reform. In the literature this is a common measure to which the price changes are compared, especially when using the tax rate changes as an exogenous variation (see, e.g., Besley (1999) and Kopczuk (2015)).

The results in columns (2)–(6) can be interpreted similarly as those presented in column (1) but the dependent variable in these specifications is the level of station-level daily diesel and gasoline prices. In addition, in these regressions we consistently control for (daily) Brent-oil prices per barrel. Also, the length of the time period vary across columns. In columns (2) and (3) we present the results using data only three months before and after the reform, and in columns (4)–(6) we present the results using data for 12 months before and after the reform. Finally, in column (5) we take potential anticipation effects into account by excluding data of 3 months before and after the reform. Thus, in this column, we use data from January 2011 to September 2011 to represent the pre-reform period, and the period from April 2012 to December 2012 to represent the post-reform period.

Column (2) shows that an increase in the diesel fuel tax increased the consumer price of diesel by 9 euro cents per liter compared to the gasoline prices (with octane rating of 95). This equals to over 90% pass-through to prices. In column (3) we use the other commonly available gasoline to form counterfactual development of prices, namely gasoline with a higher octane rating of 98. We find that the pass-through is very similar, representing 89% pass-through to prices, compared to that estimate presented in column (2). In column (4) we use data for 12 months before and after the diesel tax reform, and interact the Brent-oil prices with the diesel indicator to control for potentially differing effects of oil prices on the fuel types. The results indicate a somewhat smaller price pass-through, as the change in prices is 7.4 euro cents per liter, on average, equaling to 76% pass-through to prices.

As we discussed above in section 3.2, potential anticipation effects may be a concern in our setting. Therefore, we first exclude data for the period of three months before and after the reform to isolate these anticipation effects in column (5). The results show a slightly smaller price-response, 6.7 euro cent increase in

diesel prices compared to gasoline prices, implying 69% pass-through to prices.

Finally, in column (6), we control for the anticipation effects and the change in diesel quality by intorducing a winter dummy to the spesification, and also include both types of gasoline prices, 95 and 98 octane, to represent a counterfactual price development for diesel prices. In addition, we include several other control variables to the model. We add brand and month fixed-effects to the model, and we also include the source of price data indicator (tankkaus.com/polttoaine.net) and the count of recorded gasoline/diesel price observations by station to this spesification. Also, we interact these variables with the diesel indicator allowing for different effects for different types of fuels. These results are also our preferred estimates. The results imply a 7.1 euro cent decrease in diesel prices that results in 73% pass-through to prices.

Overall, our results are well in line with the earlier results studying the effects of taxes on pass-through to fuel prices. The results from the US suggest pass-through of 70-100%, which is very close to the estimates we present in this paper (Doyle and Samphantharak (2008), Marion and Muehlegger (2011)). Therefore, our results support the view that the incidence appear to be mostly on consumers and that the demand of fuels is relatively inelastic.

	(1)	(2)	(3)	(4)	(5)	(6)
		3 mo.	3 mo.	12 mo.	12 mo.: -3 mo.	12 mo.
VAR	Fuel tax	Price	Price	Price	Price	Price
Diesel	-0.306	-0.164***	-0.215***	-0.207***	-0.170***	-0.257***
		(0.007)	(0.009)	(0.009)	(0.003)	(0.071)
After	0.0263	0.0586***	0.0619***	0.101***	0.115***	
		(0.004)	(0.005)	(0.002)	(0.003)	
DD	0.0975	0.0897***	0.0872***	0.0737***	0.0668***	0.0711***
		(0.003)	(0.004)	(0.003)	(0.004)	(0.004)
Brent-oil price		0.003***	0.003***	0.003***	0.003***	0.0013***
		(0.0004)	(0.0004)	(< 0.0001)	(< 0.0001)	(< 0.0001)
Diesel *				< 0.001	-0.0003***	0.0001
Brent-oil price				(< 0.0001)	(< 0.0001)	(0.0001)
Constant	0.746	1.184***	1.243***	1.257***	1.182***	0.356***
		(0.048)	(0.051)	(0.004)	(0.002)	(0.064)
N		158,038	144,793	613,418	455,380	851,078
R2		0.754	0.831	0.781	0.804	0.841
Pass-through		*0.920*	*0.894*	*0.756*	*0.685*	*0.732*

Table 3: Pass-through results

5 Conclusions

Despite a large literature on the theory of tax incidence, few empirical studies have addressed the pass-through rates of excise taxes. Moreover, the existing empirical studies have focused on US data. Where fuel taxes are concerned, many European countries tax fuels heavily compared to the US, and pass-through estimates based on US data may not be very informative of fuel tax incidence with the much higher tax levels. In addition to fiscal reasons, fuel taxes are used in Europe increasingly also as an attempt to curtail CO2 emissions from traffic and to encourage the use of biofuels. Tax incidence plays an important role in the political and environmental implications of fuel taxes, as it affects the distributional impacts of fuel taxes and the effectiveness of using carbon taxes to reduce CO2 emissions from traffic.

We examine the effect of a substantial diesel tax increase, of 10.55 euro cents per liter, on the retail prices of diesel. We use a detailed data set of gas station level prices. We find evidence for less than full shifting of the tax: The estimates suggest that 70% of the tax increase was passed on to consumers. The estimated pass-through rate is somewhat smaller than found for the US in earlier studies. There may be many explanations for the difference. To the extend that short-run tax- or price elasticities for fuel demand may differ with tax- and price level, income levels, and substitution possibilities offered by the wider availability of public transportion, it is plausible that demand may be more elastic in Europe than in the US. Previous research by Alm et al. (2009) also found less-than-full pass through in rural US states, which may also be indicative of incidence in a relatively sparsely populated country such as Finland. While our results directly measure incidence only in Finland, they suggest some difference in fuel tax incidence in the US, documented in previous empirical literature, and in the relatively high-tax context in Europe.

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Appendix

Traffic fuel taxes: 2012					
Product	Pr. No.	Energy content tax	CO2 tax	Strategic stockpile fee	Total
Motor gasoline c/l	10	50.36	14	0.68	65.04
Small engine gasoline c/l	11	30.36	14	0.68	45.04
Bioethanol c/l	20	33.05	9.19	0.68	42.92
Bioethanol R c/l	21	33.05	4.59	0.68	38.32
Bioethanol T c/l	22	33.05	0.00	0.68	33.73
MTBE c/l	23	40.91	11.37	0.68	52.96
MTBE R c/l	24	40.91	10.12	0.68	51.71
MTBE T c/l	25	40.91	8.87	0.68	50.46
TAME c/l	26	44.06	12.25	0.68	56.99
TAME R c/l	27	44.06	11.14	0.68	55.88
TAME T c/l	28	44.06	10.04	0.68	54.78
ETBE c/l	29	42.49	11.81	0.68	54.98
ETBE R c/l	30	42.49	9.62	0.68	52.79
ETBE T c/l	31	42.49	7.44	0.68	50.61
TAEE c/l	32	45.64	12.68	0.68	59
TAEE R c/l	33	45.64	10.85	0.68	57.17
TAEE T c/l	34	45.64	9.01	0.68	55.33
Biogasoline c/l	38	50.36	14	0.68	65.04
Biogasoline R c/l	39	50.36	7.00	0.68	58.04
Biogasoline T c/l	40	50.36	0.00	0.68	51.04
Ethanol-Diesel c/l	50	30.7	15.9	0.35	46.95
Ethanol-Diesel para c/l	51	24	15.01	0.35	39.36
Biodiesel oil c/l	52	28.14	14.57	0.35	43.06
Biodiesel oil R c/l	53	28.14	7.29	0.35	35.78
Biodiesel oil T c/l	54	28.14	0.00	0.35	28.49
Biodiesel oil P c/l	55	24	15.01	0.35	39.36
Biodiesel oil P R c/l	56	24	7.51	0.35	31.86
Biodiesel oil P T c/l	57	24	0.00	0.35	24.35

Table 4: Excise tax rates on liquid fuels in 2012

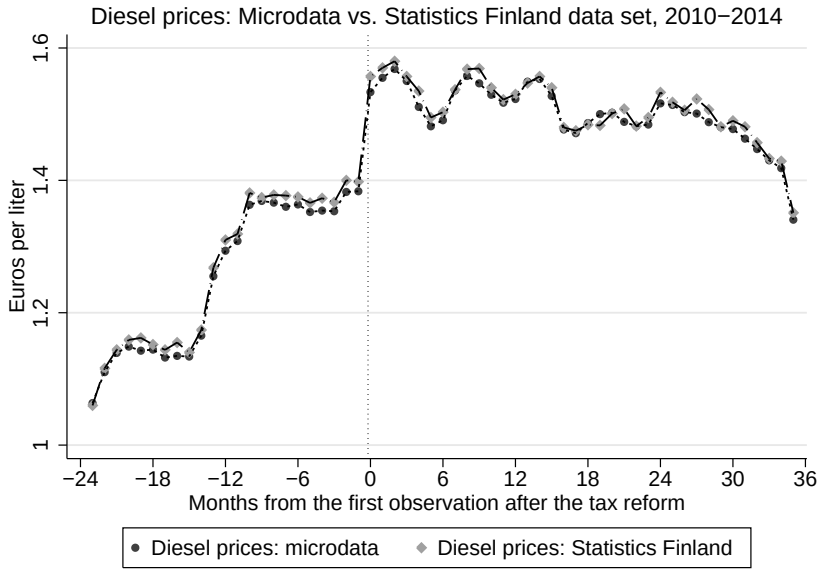

Figure 5: Average monthly consumer prices of diesel: Micro-level price data vs. CPI-data on diesel from Statistics Finland

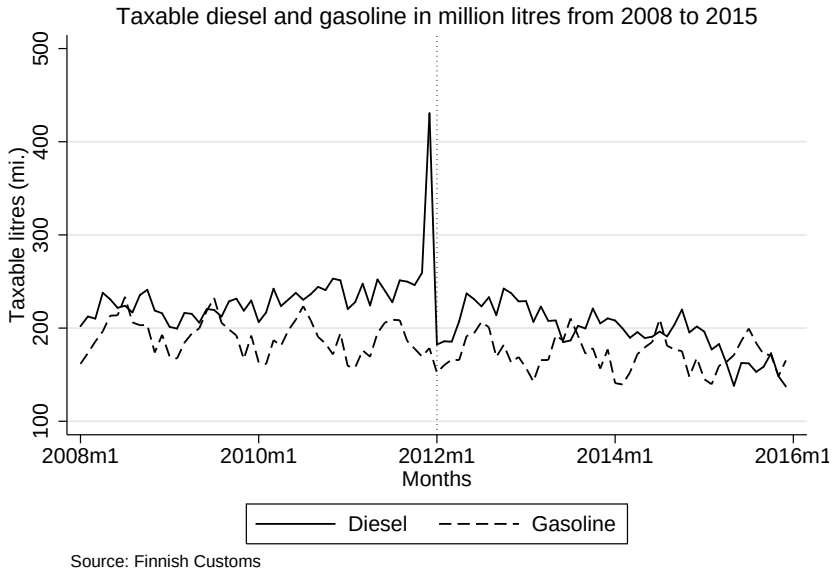

Figure 6: Taxable amount of diesel and gasoline in Finland from 2008 to 2015

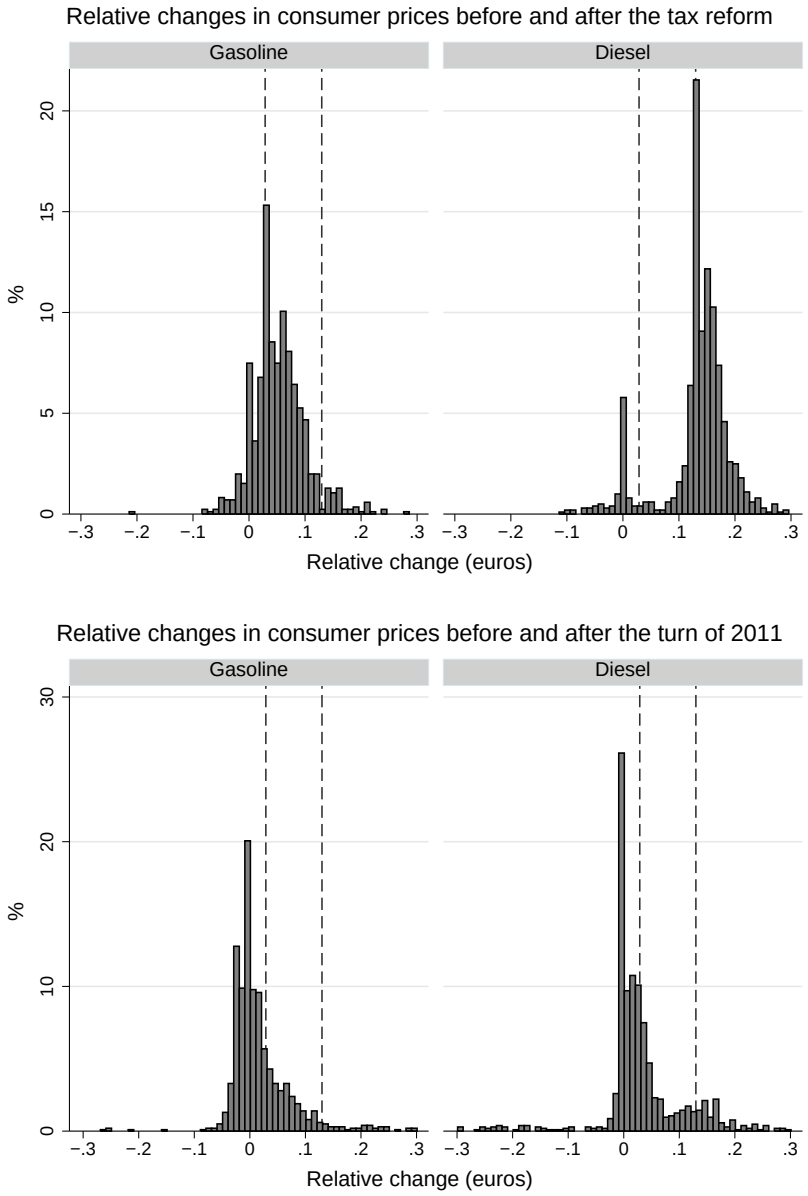

Figure 7: Relative changes in diesel and gasoline prices after the turn of year 2012