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Sean Kennedy and Sean Lyons and Edgar Morgenroth and
Keith Walsh

Economic and Social Research Institute, Revenue Commissioners,
Department of Economics, Trinity College Dublin

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Assessing the level of cross-border fuel tourism

Sean Kennedy^{a,d}, Sean Lyons^{b,c}, Edgar L. W. Morgenroth^{b,c,*}, Keith Walsh^{a,d}

^aRevenue Commissioners, Dublin Castle, Castle Street, Dublin D02 F342, Ireland

^bEconomic and Social Research Institute (ESRI), Whitaker Square, Sir John Rogerson's Quay, Dublin D02 K138, Ireland

^cDepartment of Economics, Trinity College Dublin

^dIrish Government Economic and Evaluation Service

*Corresponding author: ESRI, Whitaker Square, Sir John Rogerson's Quay, Dublin D02 K138, Ireland; email: Edgar.Morgenroth@esri.ie

ABSTRACT: Consistently cheaper fuel prices in one jurisdiction compared to a neighbouring jurisdiction should, holding other factors constant, lead to greater demand for fuel in the country with the lower price, due in part to legal fuel tourism. Fuel tourism, cross-border demand for fuel, represents an important source of tax revenues to the Exchequer but also contributes significantly to a country's national greenhouse gas (GHG) emissions. The econometric analysis in this paper aims to estimate the level and determinants of fuel demand from Northern Irish consumers in the Republic of Ireland taking account of market size, proximity to major roads, level of local competition and station characteristics. The analysis is based on an unbalanced panel dataset of retail sales among 543 border stations from April 2013 to March 2015. The results show that the set of stations close to the border have higher than expected average diesel and petrol sales by 54.4% and 14.6% respectively. Greater levels of fuel tourism for diesel may partly be attributable to heavy goods and other vehicles which avail of cheaper prices near the border before making long distance journeys on to the Continent. The combined Excise Duty, Carbon Tax and VAT contribution to the Irish Exchequer associated with fuel tourism is estimated at €202 million for diesel and €28 million for petrol based on 2015 levels. CO₂ emissions from these cross-border sales are about 1.17 million tonnes per annum, or 2% of Ireland's national GHG emissions.

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ASSESSING THE LEVEL OF CROSS-BORDER FUEL TOURISM

1. INTRODUCTION & BACKGROUND

Retail price differences between countries provide an arbitrage opportunity for consumers, and thus lead to cross-border shopping or retail tourism. Price differences across countries are often due to differences in tax or excise rates, which may lead to tax competition whereby one country sets a lower tax to attract consumers from another jurisdiction and thus increase its tax revenue, thereby putting downward pressure on commodity taxes (see Nielsen, 2001). As cross-border shopping has tax revenue implications and also affects the demand on both sides of the border, the topic has been analysed in a number of studies. For example Asplund et al (2007) found that a cut in the Danish spirit tax resulted in a reduction of Swedish spirit tax revenue of 2%.

Fuels are a commodity that is subject to significant differences in taxation across countries. While the EU sets minimum excise duties under the Energy Taxation Directive, which avoids aggressive tax competition, there are no maximum rates. A comparison of excise rates across EU member states in July 2016 reveals that the highest excise rate rates for both petrol and diesel are just over twice as high as the lowest rates. The minimum diesel rate is 8.1% lower than that for petrol and the average rate across the EU is 19.5% lower than the average for petrol resulting in lower retail prices for diesel than petrol (European Commission, 2016).

Given these differences it is not surprising that cross-border fuel shopping, or fuel tourism, takes place across many borders. Banfi et al (2005) investigated fuel tourism between Switzerland, Germany, France and Italy. They found that a 10% decrease in Swiss fuel prices would lead to a 17.5% increase in fuel demand in Switzerland, and that fuel tourism accounted for 9% of petrol sales over the period 1985 to 1997. Where fuel taxation is subject to regional variation there is also scope for 'cross boundary' fuel shopping. In Spain, motor fuel taxation rates can be altered by Autonomous Communities since 2002, and the effect of resulting fuel price differences have been investigated by Leal et al (2009). While they found the price differences induced by local variations in fuel taxation to affect behaviour, they were unable to estimate the quantity of fuel purchased by fuel tourists. Subsequent analysis by Romero-Jordan et al (2013) shows that some of the higher tax rates are partially absorbed by service stations to lessen their effect on demand.

In Ireland the tax receipts associated with motor fuel consumption are an important source of tax receipts for the Exchequer. In 2015, receipts of over €2.7 billion were collected from petrol and diesel (the largest component of receipts arises from Excise Duty but VAT and Carbon Tax also apply), provisional data indicate this increased to €2.9 billion in 2016.¹ Road transportation also contributes a significant component of Ireland's emissions of green house gases (GHGs): 11.3 million tonnes of CO₂ equivalent in 2015, representing almost 19% of Ireland's total emissions of GHGs (EPA, 2016). Interestingly, the impact of fuel tourism on GHG emissions has been largely ignored in the literature, even though it potentially transfers emissions from some countries to others.

Fuel excise rates differ significantly between the UK and the Republic of Ireland, with those in the UK being higher than those in the Republic of Ireland. For petrol the Excise rate in the Republic of Ireland was almost 13% lower in July 2016, and that for diesel was almost 30% lower. While Value Added Tax (VAT) is lower in the UK (20%) than the Republic of Ireland (23%) that still leaves a significant premium on UK fuel prices. This is particularly relevant for the consumers in Northern Ireland, who can drive to the Republic of Ireland to avail of cheaper fuel.

Due to consistently lower fuel prices in the Republic and the potential for cross-border fuel purchasing from Northern Ireland, we might expect to see increased demand for fuel at stations that are closer to the border, all other things being equal. This has positive revenue implications but negative implications in terms of Ireland's obligations on the reduction of GHGs, as the emissions from fuel sold in Ireland are assumed to arise in Ireland rather than the jurisdiction where the fuel is used. These markets thus interact in important ways with a range of policy domains, from design of taxes and tax compliance to environmental policy, and have a significant effect on consumer welfare.

Cross border shopping across the Irish border has received relatively little attention from researchers. The only comprehensive study known to us is that by FitzGerald *et al.* (1988), which was carried out at a time (the

¹ Hopkins and Walsh (2014) present a more detailed review of the contribution of oil to Excise receipts and overall tax revenues.

1980s) when indirect taxes were lower in Northern Ireland than in the Republic of Ireland. The focus was thus on consumers from the Republic of Ireland shopping in Northern Ireland. That study finds that about one third of all petrol bought by residents in the border counties was purchased in Northern Ireland. A more recent report by the National Roads Authority (NRA, 2013) indicates that, given that fuel prices in the Republic of Ireland have been lower than those in Northern Ireland since the mid 1990's, there is substantial fuel tourism from Northern Irish consumers in the Republic of Ireland. They use aggregate data to estimate that in 2011 8.6% of petrol sold in the Republic of Ireland was bought by fuel tourists from Northern Ireland. For diesel the leakage north was estimated at 22.8%.

The analysis presented here follows a different approach to that used in the NRA report. In particular it aims to estimate the level of fuel tourism, by fuel (diesel and petrol), using data of fuel sold in individual filling stations collected via Revenue's Return of Oil Movements (known as the ROM1). Our approach makes use of the fact that the level of cross border fuel tourism is a function of the trade-off between price differences and transport costs, because consumers have to travel across the border to avail of lower fuel prices. With small price differences the net benefit of crossing the border is likely to be negative except for consumers that reside close to the border.² Thus, one would expect filling stations that are located close to the border to sell more fuel than ones located further away from the border, holding all other factors equal. Therefore the difference in fuel sales between filling stations provides a means to estimate the level of fuel tourism. Our methodology thus relies on the geography of filling stations for which we have administrative data on fuel sales.

In the remainder of this paper we first describe the data employed and the specification used in our analysis. We then discuss our results and provide some observations on the findings and ideas for future research.

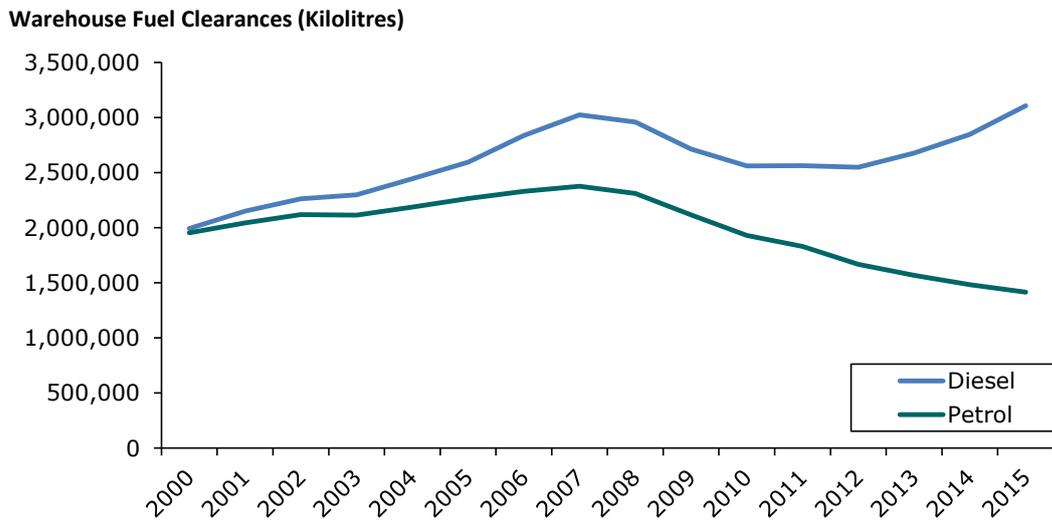
2. DATA EMPLOYED

Before discussing the data and analysis, it is useful to assess developments in the oil market in Ireland. Figure 1 shows petrol and diesel warehouse clearances in kilolitres from 2000 to 2015. Since 2010, diesel consumption has increased by 21% while petrol consumption has fallen by 27%. This reflects a transition in the oil market

² For some consumers the closest filling station might be across the border.

with an ongoing shift from petrol to diesel in the car market. In addition, with the recovery in the economy over the period, the consumption of diesel for road haulage has increased markedly (nearly all heavy goods vehicles use diesel).

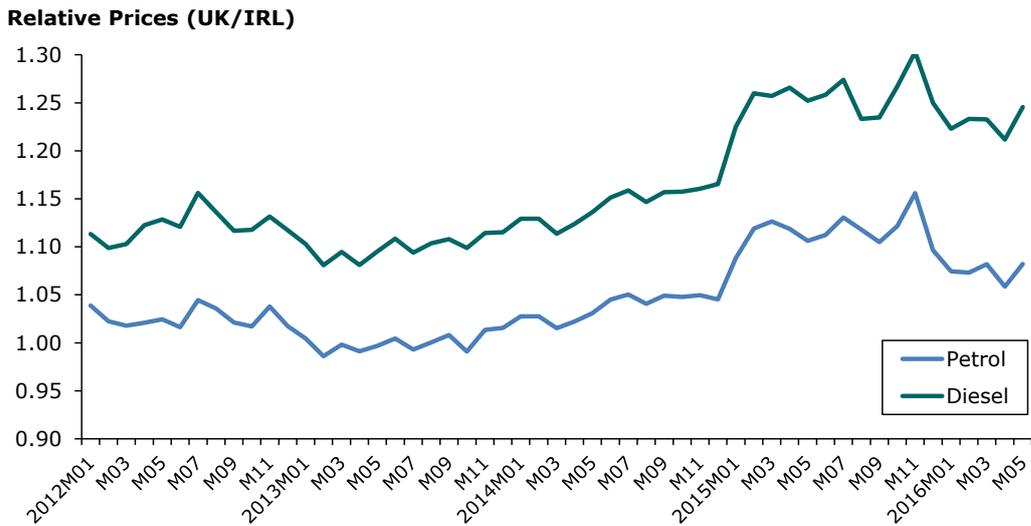
Figure 1: Fuel Clearances



Source: Revenue data. Notes: Clearances are the duty paid amounts of oil removed from tax warehouses.

Given the potential for cross border purchases, it is useful to compare prices in both jurisdictions. The data show that fuel prices are consistently cheaper in the Republic and the differences have widened in recent years. In March 2016, the Irish price of petrol and diesel per litre were 129.1c and 109.5c. By comparison, UK prices (converted to euros) for the same period were significantly more expensive at 140.0c and 141.1c respectively. The Excise on petrol and diesel is 587.71 and 479.02 per 1,000 litres and VAT is applied at the standard rate (23%) on the Excise-inclusive price.

Figure 2: Fuel Prices



In recent years Revenue has put in place a series of national initiatives to address diesel laundering and improve compliance in the oils area generally. As part of this programme, Revenue introduced a new monthly Return of Oil Movements (ROM1) in January 2013. While the purpose of this new reporting requirement is to provide data to assist Revenue in addressing diesel laundering in the fuel trade, it also represents new opportunities for microeconomic research.

This return is mandatory for authorised warehousekeepers, distributors and forecourt retailers. The oil information required in the return covers opening and closing balances, each inward and outward movement of stock by product type in addition to information on date, quantity, invoice, customer and supplier. Using this information, a detailed supply chain analysis can be constructed of all major movements of oil within the state.

It should be borne in mind that the ROM1 return and data are designed for the purposes of assisting Revenue in ensuring tax compliance in the oil fuel sector, rather than for analysis of fuel tourism or other issues. A number of caveats to the data should be noted when considering the results later in this paper.

Definitional issues between traders may arise where it is unclear whether a trader is a forecourt, distributor or warehouse. While we have made every attempt to only include traders who are forecourts, or who have the characteristics of forecourts, there is sometimes an unclear distinction between these trader types which mean our data may include some warehouses or distributors.

Self-reporting issues arise where there are two counterparties to a trade (there are inward and outward trades along the supply chain and both traders make declarations for a trade) but the volumes delivered and received differ. Where there is a difference or a reported mismatch, this may become problematic if we cannot identify the same trades due to the mismatch in reporting, which can in effect lead to double-counting. In a best case scenario, we can identify it is the same trade and we then must choose (arbitrarily) one of these trades to use for analysis.

Complexities also arise where traders have multiple licenses and can receive fuel through one license and sell it through another. It can be challenging to identify intra-company trades. Multiple licences are most likely among larger traders and this can again lead to potential double-counting.

Notwithstanding the above, the ROM1 is a unique data source and forms the basis for analysis in this paper.

The ROM1 data is based on monthly oil movement trades at each link in the supply chain from warehouse (215,000 trades) to distributor (1.3 million trades) to retail station level (675,000 trades). The current analysis is based on an unbalanced panel dataset of outward retail sales among the 543 stations close the border with Northern Ireland³ over the 24 month period April 2013 to March 2015. Extensive data preparation was undertaken including matching X-Y coordinates of stations.

³ Included are all the stations in the counties that have a border with NI.

Figure 3: X-Y Coordinates of All 543 Border Stations



Source: Revenue data and authors' analysis.

3. SPECIFICATION

The econometric analysis in this section aims to estimate the extent and determinants of fuel sales by stations in the border counties taking account of market size, proximity to major roads, level of local competition and station characteristics.⁴

Random effects models are employed for both the petrol and diesel markets. All variables are transformed to natural logarithms with the exception of the number of stations within ten kilometers and also binary and categorical variables. Diagnostic testing indicates that the random effects model is preferable to OLS. Serial correlation was identified in the panel models using the Wooldridge test. As one might expect, there is a lot of

⁴ While fuel tourism occurs in all parts of the country to some degree (and indeed by Irish residents abroad), the focus in this analysis is on Northern Ireland consumers and the border stations where such cross border purchasing is likely to be most significant.

persistence in behavior, i.e. fuel sales in the recent past influence future sales. To correct for this in the model, an autoregressive disturbance term is included.⁵

Ideally our models would control for the effects of changing absolute price levels and price relativities with Northern Ireland. Unfortunately, only data on average prices for each jurisdiction are available, not prices charged by each station. We tried estimating the models with monthly Irish and UK petrol and diesel prices, but the limited variation in prices changes meant that the estimated price effects lacked statistical significance. This means that we can only assess the average level of cross-border sales during the period, not the marginal effects that might be expected on cross-border sales if taxes or price components were to change.

The determinants of quantity of fuel sold are estimated first using a full model as follows:

$$(1) \quad Q \ln(\text{Fuel})_{xyit} = \alpha_0 + \beta_1(\text{DisttoBord})_{xyit} + \beta_2(\text{Near Major})_{xyit} + \beta_3(\text{No10k})_{xyit} + \beta_4 \ln(\text{Comp})_{xyit} + \beta_5 \ln(\text{Pop})_{xyit} + \beta_6 \ln(\text{Cars})_{xyit} + \beta_7 \ln(\text{Comms})_{xyit} + \beta_8 \ln(\text{WniPop})_{xyit} + \beta_9 \ln(\text{WniCars})_{xyit} + \mu_i + \varepsilon_{it} \quad (i = 1, \dots, N; t = 1, \dots, T)$$

A preferred parsimonious model is then estimated after dropping insignificant regressors:

$$(2) \quad Q \ln(\text{Fuel})_{xyit} = \alpha_0 + \beta_1(\text{DisttoBord})_{xyit} + \beta_2(\text{Near Major})_{xyit} + \beta_3(\text{No10k})_{xyit} + \beta_4 \ln(\text{Pop})_{xyit} + \mu_i + \varepsilon_{it} \quad (i = 1, \dots, N; t = 1, \dots, T)$$

Where:

- *Fuel_i* denotes the dependent variable in the models, which is the total amount of monthly diesel or petrol sold in litres at the retail station;
- *DisttoBord_i* – a categorical variable of the shortest driving distance to the border in kilometres. The categories are less than or equal to one kilometre, one to three kilometres, three to five kilometres and greater than five kilometres.
- *NearMajor_i* – a binary variable equalling one if the stations is within 0.5 kilometres of a major road;
- *No10k_i* - number of stations within a 10km radius;

⁵ Autocorrelation based on Durbin-Watson.

- $Comp_i$ - average distance to the stations within 10km radius
- Pop_i – the population and spatially weighted population in the Electoral Division (ED) in which the station is located in 2011 from the Census;
- $Cars_i$ - denotes the number of cars per household and the spatially weighted number of cars in the ED in which the station is located in 2011 from the Census;
- $WCars2011_i$ - spatially weighted cars. The spatial weights matrix is a distance matrix;
- $Comms_i$ – the number of commuters and the spatially weighted number of commuters based on Census 2011;
- $WniPop_i$ – spatially weighted population for Northern Ireland;
- $WniCars_i$ – spatially weighted cars for Northern Ireland;
- The term ε_i is the stochastic term of the model (capturing other possible influences on quantity of fuel sold not included in the model, for example the price of fuel);
- The terms α and β refer to the parameters of the model to be estimated.

4. RESULTS

Petrol Market

Table 1 presents coefficients and standard errors (in parenthesis) for the quantity of petrol sold (in litres) on distance to the border, number of competitors and other market size variables.

The results show that stations closer to the border have higher petrol sales than would be expected given their other characteristics. Stations within 1 kilometre of the border, sell 1% more petrol compared to those 5 kilometres or more away. Stations within 0.5km of a major road have 0.2% higher petrol sales. Stations with greater numbers of competing stations within 10km have lower petrol sales. An increase in the population within the ED is associated with a large positive impact on petrol sales.

Table 1: Determinants of Petrol Demand

	Preferred Model	Full Model
3 – 5km	0.276 (0.23)	0.717** (0.256)
1 – 3km	0.801** (0.281)	1.567*** (0.308)
<= 1km	1.094*** (0.2)	1.858*** (0.212)
Near Major Roads	0.223* (0.107)	0.307* (0.125)
Log no. competing stations within 10km	-0.013* (0.006)	-0.015 (0.008)
Log distance to stations within 10km		-0.074 (0.107)
Log pop & pop density	0.677*** (0.064)	0.819*** (0.195)
Log cars & cars density		0.641 (0.36)
Log commuters & commuters density		-0.094 (0.165)
Log pop density northern Ireland		-29.624 (35.161)
Log cars density northern Ireland		27.188 (20.879)
Station-Year Observations	8,913	8,913
Stations	427	427
R-squared	0.30	0.30

Source: authors' analysis. Notes: All variables in logs. * for $p < .05$, ** for $p < .01$, and *** for $p < .001$.

Diesel Market

Table 2 presents the results for the diesel market. According to the modelling, stations within 1 kilometre of the border, sell 1.8% more diesel compared to those 5 kilometres or more away. Stations within 1 – 3 kilometres sell 1.5% more. Results also show expected signs on proximity to major roads, the density of local competitions as measured by the number of competing stations within 10km and population levels in the ED.

Table 2: Determinants of Diesel Demand

	Preferred	
	Model	Full Model
3 – 5km	0.692** (0.256)	0.319 (0.231)
1 – 3km	1.479*** (0.304)	0.910** (0.285)
<= 1km	1.801*** (0.202)	1.172*** (0.213)
Near Major Roads	0.390** (0.12)	0.168 (0.112)
Log no. competing stations within 10km	-0.018* (0.007)	-0.017* (0.007)
Log distance to stations within 10km		0.189* (0.09)
Log pop & pop density	0.656*** (0.073)	1.000*** (0.169)
Log cars & cars density		0.525 (0.307)
Log commuters & commuters density		-0.193 (0.144)
Log pop density northern Ireland		-4.306 (31.919)
Log cars density northern Ireland		6.541 (19.055)
Observations	8,127	8,127
Stations	396	396
R-squared	0.31	0.30

Source: authors' analysis. Notes: All variables in logs. * for $p < .05$, ** for $p < .01$, and *** for $p < .001$.

Greater levels of fuel tourism for diesel may partly be attributable to heavy goods and other vehicles which avail of cheaper prices near the border before making long distance journeys on to the Continent. Descriptive analysis from the data shows that diesel sales are typically higher than petrol sales, again partly reflecting sales to large capacity heavy goods vehicles. Diesel also has much greater monthly within-station variation. This may be explained by diesel generally being used for more long distance journeys, for example by taxis.

5. FUEL TOURISM

Fuel tourism, in this analysis cross-border demand for fuel from Northern Irish consumers, represents an important source of tax revenues to the Exchequer. Consistently cheaper fuel prices in the Republic should, holding other factors constant, lead to greater demand for fuel in the border region due in part to legal fuel tourism.

Fuel tourism should be more substantial close to the border as the transport costs to locations further away from the border erode the price differential for fuel between Northern Ireland and Ireland. This implies that *ceteris paribus* stations close to the border would sell more fuel than those further away. The difference in fuel volume sold between two otherwise identical stations with one close to the border and one far away from the border should then be due to fuel tourism.

To estimate this marginal effect associated with proximity to the border, average petrol and diesel sales predictions are first obtained for the preferred models. Next, a simulation model is run where all of the border stations are assumed to be away from the border. The difference between models provides an estimate of the quantities associated with tourism which is shown for both petrol and diesel markets in Table 3.

The results show that the set of stations close to the border have higher average petrol and diesel sales by 14.6% and 54.4% respectively. The findings suggest significant levels of fuel tourism, particularly in the diesel market.

Table 3: Fuel Tourism Estimates (monthly average)

	Preferred Model Prediction with Proximity Effects Set to Zero	Preferred Model Prediction	% Difference
Petrol	48,844 (33,032)	55,957 (37,793)	14.6%
Diesel	34,183 (22,360)	52,796 (51,962)	54.5%

Source: Authors' analysis. Notes: Standard deviation in parenthesis.

TAX CONTRIBUTION OF FUEL TOURISM

To estimate the tax contribution from fuel tourism, the analysis in the above section using the ROM1 data is extrapolated to Revenue's warehouse clearance data. The clearances data provide a complete picture of all petrol and diesel released for sale on the Irish market. Annual warehouse clearances also provide a proxy for annual station fuel sales because the majority of fuel cleared from warehouses will eventually be sold through forecourts.

As noted in the earlier section describing the ROM1 data, there are some issues around definitions and reporting that may lead to some potential double counting. While these are not expected to bias the econometric analysis, the clearances data present a preferable data source for the overall picture of petrol and diesel in the State.

In 2015, Revenue warehouse clearances data show clearances of 3.1 million kilolitres of auto diesel and 1.4 million kilolitres of petrol. The Excise (plus VAT and Carbon Tax) associated with the above diesel and petrol clearances were €1,308 million (€232 million) and €768 million (€426 million) respectively.

Based on an approximate estimate using Revenue's ROM1 data, the border stations comprise 24% and 16% of the diesel and petrol markets in the Republic. This implies diesel and petrol sales (in kilolitres) in the border area of 749k and 231k.

Given that the set of stations near the border sell an average of 54% and 15% more diesel and petrol compared to stations far from the border, this suggests that the border stations as a whole sell an additional 408k in diesel and 34k in petrol, beyond what they might otherwise sell if they were not close to the border. Finally, assuming the same ratios of tax (Excise, Carbon and VAT) per kilolitre sold⁶, the overall annual tax contribution of fuel tourism is €28 million for petrol and €202 million for diesel – based on 2015 receipts levels.

Table 4: Estimates of Fuel Tourism

	Diesel	Petrol
Fuel Tourism (Kilolitres)	407,686	33,697
Excise (€)	171,646,999	18,282,530
Carbon (€)	20,759,647	1,482,604
VAT (€)	9,661,822	8,663,133
Total Tax (€)	202,068,468	28,428,266

Source: Revenue data and authors' analysis. Notes: 1. Clearances refer to the amounts of fuel cleared from tax warehouses. 2. Border station contribution estimated from ROM1 data with outlier stations removed. 3. VAT associated with clearances data is estimated, VAT is significantly lower for diesel because diesel is largely purchased by VAT registered businesses which claim a credit and get repayments (there is no such credit for petrol).

6. GHG EMISSIONS ASSOCIATED WITH FUEL TOURISM

The estimated quantity of fuels sold to cross-border consumers leads to emissions of about 1.17 million tonnes of CO₂, based on emission and conversion factors published in SEAI (2016a, 2016b). To put this quantity of emissions in perspective, it corresponds to just under 2% of Ireland's total GHG emissions in 2015 or 10.4% of road transport emissions.

⁶ The official rates per 1,000 litres are on the Revenue website:
<http://www.revenue.ie/en/tax/excise/duties/excise-duty-rates.html>

7. OBSERVATIONS ON THE RESULTS AND TOPICS FOR FUTURE RESEARCH

The extent of Ireland's "fuel tourism" estimated in this paper is lower than most previous estimates made using aggregate data from earlier periods. We estimate that 13% of diesel sales were to cross-border consumers during 2013-15, compared to 15-25% from studies surveyed in NRA (2013). Our estimated cross-border share of petrol sales is 2.4%, compared to their range of 5-18%. Nevertheless, the scale of cross-border activity is significant in terms of the tax revenue associated with it and the share of Ireland's national GHG emissions it represents.

From a policy perspective, it would also be interesting to know how much cross-border fuel sales would be affected by small changes to relative prices. We were unable to answer this question due to data limitations, in particular the absence of data on prices at the level of individual retail fuel stations. Although stations are required to make these data public, they are not captured in a comprehensive database. If price data could be linked to the quantity data provided by ROM1 forms, it should be possible to simulate the effects of hypothetical tax changes and also to model the retail petrol market in a more detailed way.

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