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* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

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Fuel tourism in Dutch border regions: Are only salient price differentials relevant?*

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Abstract

Using detailed data on consumer payments, we find only limited evidence that fluctuations in cross-border fuel price differentials are relevant for Dutch consumers. Consumers living close to the German border did react to a salient increase in Dutch excise fuel duties in January 2014. However, the increase of fuel tourism was only temporary. Secondly, there are no robust indications that fuel tourism is relevant for Dutch consumers living further than 10 kilometres from either the border with Belgium or Germany. The apparent absence of fuel tourism may either be explained by the widespread use of loyalty cards or by the low level of international commuting by Dutch workers.

Keywords: fuel tourism, consumer data, payment diaries, excise duties.
JEL classifications: D12, H23, Q41.

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1. INTRODUCTION

This paper finds that salience of fuel price differentials can be important in explaining the incidence of cross-border fuel purchases. In doing so, our paper contributes to the literature on fuel tourism.[1] The empirical approach in most papers is to use aggregate consumption data. For instance, Banfi, Filippini, and Hunt (2005) use yearly data on gasoline consumption to study fuel tourism in the border regions of Switzerland. They estimate that a 10% decrease of the Swiss gasoline price increases demand by nearly 17.5%. Leal, López-Laborda, and Rodrigo (2009), who use monthly transaction data, show that fuel tourism can also occur between regions. They estimate that relatively higher prices in Catalonia and Madrid raise the long-term demand for fuel in Aragon. Romero-Jordán, García-Inés, and Álvarez García (2013) find, in addition, that at borders with high excises, price shocks are not fully passed on to consumers, suggesting that retailers are sensitive to the likelihood of fuel tourism. Using data from gasoline retailers for four tax regions in the United States, Manuszak and Moul (2009) estimate that the consumers' willingness to travel an additional mile to buy gasoline is between USD 0.065 and USD 0.084.

An important innovation of our paper is the availability of information on purchases made by a large sample of individual consumers. The transactions which are recorded cover each day in the period between September 2013 and June 2015. Our paper uses this data on consumers' transactions to study the general incidence of fuel tourism in the border regions of the Netherlands over time.[2] Relative to previous studies, we find surprisingly little evidence for shifts in fuel demand related to fluctuations in fuel price differentials. Using a range of

[1] Cross-border purchases have been studied more widely, for example in the context of cigarettes and alcohol consumption (Asplund, Friberg and Wilander, 2007; Chiou and Muehlegger, 2008). Engel and Rogers (1996) is a seminal contribution that studies pricing differentials across borders.

[2] Rietveld, Bruinsma and Van Vuuren (1999) find "substantial variability among people in their responses to the option of fuelling abroad." In 1997 30% of the Dutch car owners living near the German border would fuel in Germany in case of a price differential of 10 eurocents per litre, and 5% of the Dutch living at a distance of at least 30 km from the German border would buy fuel in Germany. They examine the impact of a tax increase introduced on 1 July 1997 on the incidence of fuel tourism using consumer data prior to the tax increase (April – June 1997) and after it (September – October 1997).

regression models, we estimate that petrol demand of Dutch car owners living close to the border is fairly inelastic with respect to cross-border differences in fuel prices. This finding would suggest that changes in fuel excise duties have limited effect on fuel demand in border regions. Possible reasons for the weak evidence for fuel tourism include the widespread use of loyalty card programs and the low level of commuting from the Netherlands to Germany or Belgium.

At the same time, we do find evidence that during some periods the incidence of fuel tourism can increase. In particular, we estimate a strong decline in fuel purchases at Dutch gas stations following a widely debated increase of Dutch fuel excise duties in January 2014. This finding suggests that the salience of the price differential is an important factor in determining the incidence of fuel tourism.

Furthermore, we find that the impact of this widely debated price increase was temporary, as the decline in fuel demand is restricted to the quarter in which the higher excise duties were introduced. We rationalise the temporary increase in fuel tourism by pointing to the fact that most of the public debate did not distinguish between the products for which the higher excise were introduced. In fact, for most consumers the price differential did not increase much following the increase in excises, as these increases primarily applied to diesel and LPG, and to a much smaller extent to gasoline. The temporary nature of the decrease in fuel demand suggests a learning process in which consumers realised that the price differentials were insufficiently large to make prolonged fuel tourism attractive.

The remainder of this paper is organised as follows: Section 2 discusses background information on fuel price differentials between the Netherlands and Belgium or Germany. Section 3 discusses the collection of the detailed transaction data by individual consumers, offers descriptive statistics, and discusses the methodology. Section 4 outlines the main results, while Section 5 offers concluding comments.

2. BACKGROUND ON DUTCH FUEL PRICES AND DIFFERENTIALS

As background, we first discuss the relevant features of fuel price formation in the Netherlands, where we also discuss the role of excise duties. With respect to the description of fuel price formation in the Netherlands, we heavily rely on Faber (2010). Oil companies announce suggested gasoline prices on a daily basis, which are publically available. In practice, these suggested prices act as a reference price for gas stations. Subsequently, dealer operated gas stations may decide themselves whether to give a discount on the suggested price or not. It turns out that gas stations along the highway follow the suggested fuel prices exactly, but gas stations located elsewhere give discounts which they advertise explicitly. According to Faber (2010) the regime of suggested prices 'has a coordinating effect across brands and within brands'. He also investigates the occurrence of asymmetric pricing by gasoline stations, meaning that prices rise more rapidly after a cost increase than they go down in case of a cost decrease. About 38% of the gas stations price asymmetrically. Characteristics of asymmetrically pricing gas stations turn out not do not differ from those of other gas stations. Also distance to the German or Belgian border does not influence gasoline stations price setting. This is an important finding for our study as it indicates that gas stations located nearby the border do not react differently on increases in excise duties than gas stations located further away from the border.

We use information on fuel prices from the Oil Bulletins that are published weekly by the European Commission (EC). The prices listed in these Bulletins refer to prices effective on Monday.[3] Figure 1 displays information on the price levels in the Netherlands and its two

[3] We do not have access to daily data from individual gas stations, in contrast to Faber (2010). The reason is straightforward: These data are only available on the day itself, but not retrospectively. Therefore, we relied on fuel price information provided by the European Commission. Each week, the EC publishes an Oil Bulletin including average fuel prices for each of the 28 Member States of the EU. The fuel prices refer to consumer prices effective on Monday, distinguishing between prices for gasoline (unleaded), diesel and LPG. The Oil Bulletin provides information on prices including and excluding taxes and excise duties. The Member States are responsible for reporting the required information to the EC. Statistics Netherlands collects price information for the Netherlands based on information from 3,800 gas stations out of approximately 4,200 gas stations. The German Federal Ministry of Economy and Technology collects price information from international oil companies and independent gas stations for Germany. For each fuel type the market coverage is at least 70 per cent. Belgium has information from different reporting bodies. The prices are collected from a sample of 30 gas stations, which is modified on a weekly basis and covers all types of gas stations (from oil companies, independent operators and large stores).

neighbouring countries (Belgium and Germany) for three fuel types (gasoline, diesel, and LPG). The period is July 2013 to June 2015.

Insert Figure 1 around here

During this period, gasoline is generally more expensive in the Netherlands than in the neighbouring countries. The percentage difference starts around 6 per cent in mid-2013, before increasing to around 10 per cent in early 2014. Gasoline is by far the most common fuel that Dutch consumers use and, as such, one could expect a constant incidence of fuel tourism.

In comparison, concerning diesel and LPG, it is only from 2014 onwards that these products are more expensive in the Netherlands than in Belgium or Germany. This shift in relative prices is mainly due to an increase of excise duties on LPG and diesel in January 2014. At that time, the excise duty on diesel was raised by 3.8 cent per litre, making this type of fuel around 4 – 6 per cent more expensive compared to Belgium and Germany. For LPG, the excise duty was raised by 7.7 cent per litre, which created a price gap with Germany of around 10 per cent and a price gap with Belgium of up to 20 per cent.

A further feature is that the variability in price differentials varies across the three fuel types. In general, price differentials for gasoline and diesel are persistent, while we see large swings in LPG differentials.

3. DATA AND METHODOLOGY

3.1 Data

This paper uses a unique panel data set based on consumer payment diaries. The data contains information on payments made by 55,909 Dutch residents (aged 12 years and older) between

September 2013 and June 2015. The data were collected by research company GfK. From this full sample, we exclude respondents younger than 18, which is the minimum age for driving a car in the Netherlands) and respondents who do not own a car. In the end, the sample consists of 35,766 respondents.[4]

Concerning the coverage, we have observations that span all weekdays and all weeks within a month. Therefore, we can examine the impact of changes in the level of excise duties of fuel prices on fuel tourism over time. Respondents in the survey participate at most once every quarter - in order to minimize the burden on the respondent. Thus, the final data set we use for the empirical analysis is an unbalanced panel of 35,766 quarterly consumer-level observations from September 2013 to June 2015. On average, respondents participate 1.7 times within this time frame, leading to 60,272 registration days. In total, the respondents report 5,776 payments at gas stations in the Netherlands.

The survey was originally designed to estimate cash and card usage at points-of sale in the Netherlands.[5] Each day of the year, a different group of consumers was asked to participate in a two-part survey. The first part of this survey consists of a one-day diary, where consumers register their payments at points-of-sale during one day in a diary. The particular day is pre-defined by GfK in order to ensure that all days within a year are adequately covered.[6] For each payment respondents register a wide range of information: the means of payment, the amount paid, and the industry. Regarding the industry, respondents choose between 14 industries, including gas stations.

[4] Only when respondents own a car they have to pay their fuel themselves and are expected to react on cross-border fuel price differentials. If they have a company car or a leased car, the employer or the leasing company pays their fuel purchases. Unfortunately, we are not able to identify whether car drivers own a car, lease a car or use a company car, so we can't exclude respondents from our analysis without a private car. Any effects we find in this paper regarding the impact of cross-border fuel price differentials on fuel tourism may be considered as lower bounds.

[5] See Jonker, Kosse and Hernandez (2012) for more detailed information about the usage of diaries to estimate cash and card usage in the Netherlands. DNB/DPA (2015) provides results for 2014.

[6] Jonker and Kosse (2013) shows that one-day transaction diaries are the preferred methodology for collecting data among consumers for analysing payment behaviour. Retrospective interviews or one-week registration methods leads to less accurate registration of payment transaction by respondents due to incomplete recall, diary fatigue or diary exhaustion. A one-week diary misses about 40% of the transactions that are tracked in a one-day diary.

The second part of the survey consists of an additional questionnaire which was filled in the day after the one on which individuals kept a payment diary. Respondents could complete the questionnaire in two ways: either they filled in an online survey or they were interviewed by phone. In this questionnaire, respondents report among other things information from their payment diary, ancillary information about these payments, and information about their payment behaviour in general.

The dataset also contains a rich set of background information, including the 4-digit ZIP code of the respondent's residence. We use information from Statistics Netherlands (2014) on the distance between 4-digit ZIP codes to the German and Belgian border to construct variables measuring the distance between the respondent's residence to the German and Belgian border. Statistics Netherlands distinguishes four categories: 0 - 10 km, 10 – 20 km, 20 - 30 km and 30 km and more. Using the information on ZIP-codes, Figure 2 shows the location where the respondents in our sample live. Here, we restrict the sample to those respondents living in one of the seven border provinces. In the regressions, we will also work with this sub-sample. Figure 2 indicates that our data set has a good coverage for all the border provinces.

Insert Figure 2 around here

As noted above, we use weekly information on fuel prices in the Netherlands, Belgium and Germany. These data are sourced from the weekly published Oil Bulletins by the EC. We use this data to construct relative fuel price differentials between the Netherlands, Belgium and Germany as:

$$PD_{c,i,t} = 100 * (P_{c,i,t} - P_{NL,i,t}) / P_{NL,i,t} \qquad (1)$$

where *i* indexes the three fuel types (gasoline, diesel, and LPG), *c* indexes the two neighbouring countries (Belgium and Germany), and *t* indexes the weeks. Negative values for PD indicate that the particular fuel type in a given week is more expensive in the Netherlands.

Unfortunately, it is not possible to match the respondents with the particular fuel type of their cars. Therefore, we construct weighted average fuel price differentials as a proxy of the fuel price differentials relevant for the respondents. The weighted average price differentials are based on the price differentials for gasoline, diesel and LPG, weighted by their share in the Dutch passenger car market. According to BOVAG/RAI (2015), around 79 per cent of Dutch passenger cars in 2014 used gasoline, 17 per cent used diesel cars and 2 per cent LPG.[7] We use 4-week moving average prices in order to take into account that consumers may not react immediately to changes in fuel prices.

3.2 Descriptive statistics

Table 1 provides summary statistics of the demographic characteristics of the respondents. A substantial share of the respondents live near the German or Belgian border; about 8 per cent live within 10 km distance of the German border, 7 per cent live between 10 to 20 km from it and another 4.5 per cent live between 20 to 30 km of the German border. Regarding the distance to the Belgian border, 5 per cent of the respondents live within a distance up to 10 km of it and 9 per cent between 10 to 20 km and 5 per cent between 20 to 30 km from it. The share of respondents buying fuel is 10 per cent, i.e. on average car drivers buy fuel at Dutch gas stations every 10 days. The probabilities range between 9.6 per cent for people living within 10 km distances to the German border to 11.7 per cent for people living 10 to 20 km from the German border.

[7] The remaining 2 percent use alternative fuel. We correct the shares for gasoline, diesel and LPG, so that the shares add up to 100%.

insert Table 1 about here

At first sight, it seems that the probability that a car driver buys fuel at a gas station in the Netherlands hardly varies with the distance of his/her residence to the border. However, when we examine the share of people buying fuel by quarter of the year and distance to the border we see that the share of people who buy fuel at Dutch gas stations and who live within 10 km from the border drops from 10 per cent to 8 per cent between the last quarter of 2013 and the first quarter of 2014 (see Figure 3). A similar drop is visible between the last quarter of 2014 and the first quarter of 2015. Such declines are not visible for people whose residence is farther away than 10 km from either the German or Belgian border km. These drops may be a first indication that the Dutch car drivers living up to 10 km from the Dutch border react on increases in fuel prices or increases in excise duties on fuel, by reducing domestic demand. However, excise duties only seem to depress domestic demand for at most one quarter, suggesting that the impact of rises in excise duties only have a temporary effect on domestic demand for fuel in the Netherlands.

insert Figure 3 about here

3.3 Methodology

We use a series of fairly simple panel data linear probability regression models to analyse consumers' responses to fuel price differentials. As the respondents were drawn from the Dutch population we assume that the individual specific constant terms are randomly distributed across individual respondents. The binary dependent variable D_FUEL_{it} is equal to 1 in case respondent *i* records a payment at a Dutch gas station on a given day *t*, and zero otherwise.

First, we estimate a baseline model in which we assess the influence of consumer characteristics X_{it} and calendar effects C_t on the likelihood that car drivers buy fuel at a Dutch gas station.

$$D\_FUEL_{it} = D\_FUEL_{it}(X_{it}, C_t) \qquad (2)$$

We include the following covariates: gender, age, household size, income level, educational level, urbanisation degree and province of his/her residence. The reference person is a woman, between 45 – 65 years of age, having an intermediate educational level and an intermediate income level (annual gross income between EUR 23.4K and EUR 51.3K). In addition, we include dummy variables reflecting the province where the respondent is living as well as dummy variables reflecting the day of the week (reference day is Monday), week of the year (reference is week 53), and year (reference is 2015) in order to control for any calendar effects. We estimate the baseline model for various samples. We start with the full sample, before focusing on respondents who live in one of the seven border provinces (Drenthe, Gelderland, Groningen, Limburg, Noord-Brabant, Overijssel and Zeeland). In a third model, we distinguish whether respondents live close to the Belgian or German border.

In the second step, we include variables reflecting relative fuel price differentials between the Netherlands and its two neighbouring countries as well as dummy variables reflecting the distance to the Belgian or German border. We also include interactions between price differentials and distance to the border, as the literature (see e.g. Kanbur and Keen, 1993; Manuszak and Moul, 2008) predicts that the influence of price differentials diminishes with the distance that car drivers have to drive to cross the border. We estimate two models: one for people living in one of the provinces close to the Belgian border and one for people living close to the German border. For both borders, we construct dummy variables D_B_{it} and D_G_{it}

reflecting the distance between the respondent's residence at time *t* to the Belgian respectively the German border (< 10 km, 10 – 20 km, 20 – 30 km, reference: >= 30 km).

$$D_{FUEL_{it}} = D_{FUEL_{it}}\left(X_{it}, C_t, D\_B_{it,}, PD_{Bt}, PD_{Bt}xD\_B_{it}\right) \qquad (3a)$$

$$D_{FUEL_{it}} = D_{FUEL_{it}}\left(X_{it}, C_t, D\_G_{it,}, PD_{Gt}, PD_{Gt}xD\_G_{it}\right) \qquad (3b)$$

In the third and final step, we assess whether changes in excise duties affect car drivers' fuelling behaviour, other than via their pass-through in consumers' fuel prices. We do so by introducing quarterly dummies Q_t in the set of covariates and interaction terms QxD_B_{it} and QxD_G_{it} between the quarterly dummies and dummy variables reflecting the distance to the Belgian or German border. This enables us to assess whether the magnitude and the duration of any effect of changes in excise duties differs by distance to the border. We estimate two models: one for people living in one of the provinces close to the Belgian and one for people living in one of the provinces close to the German border. [8]

$$D_{FUEL_{it}} = D_{FUEL_{it}}\left(X_{it}, C_t, D_{B_{it,}}, PD_{Bt}, Q_t, PD_{Bt}xD_{B_{it}}, \; QxD_{B_{it}}\right) \qquad (4a)$$

$$D_{FUEL_{it}} = D_{FUEL_{it}}\left(X_{it}, C_t, D_{G_{it,}}, PD_{Gt}, Q_t, PD_{Gt}xD_{G_{it}}, QxD_{G_{it}}\right) \qquad (4b)$$

4. ESTIMATION RESULTS

4.1 Assessing the impact of demographic characteristics and calendar effects

Table 2 shows the parameter estimates and standard errors (in italics) for a selection of the explanatory variables in the benchmark random effects linear probability model.[9] We find a number of intuitive results for the characteristics of consumers, which indicates that our dataset

[8] Respondents living in one of the seven border provinces (Limburg) often live close to *both* the Belgian and German border. In the empirical regression, we will take this into account by looking at various sub-samples.

[9] Estimated parameters and standard errors of all covariates, including all calendar and province effects are available upon request. We also ran random effects probit models, the estimates of which are comparable to those reported in the paper.

is suitable for analysing the determinants of fuelling behaviour. For instance, we find that car-driving males are 5 per cent more likely than females to buy fuel at a Dutch gas station. This finding corresponds with the fact that men drive cars relatively more often and over longer distances than women.[10] In addition, age, income, household size and degree of urbanisation of the respondent's residence are factors that influence the likelihood of purchasing fuel at a Dutch gas station. With respect to age, we find that both relatively young and relatively old consumers are less likely to buy fuel than respondents between 45 - 54 years of age.[11] A possible explanation for young people may be that some of them still live with their parents and actually use their parents' car (and not their own) and do not have to buy fuel themselves. There may be several reasons why elderly people buy less fuel. They may drive less and need less fuel than people in the reference group as they do not need to commute to work, or because they are more likely to have physical problems which makes it difficult to drive a car. It may also be that they buy fuel relatively often across the border. The estimation results suggest that people aged 55 and older who live near Belgium are 1 per cent less likely to buy fuel than the average Dutch consumer aged 55 and older (column 1 versus column 3). For them the additional savings from buying fuel at a Belgian gas station may outweigh their costs, due to their lower opportunity costs of time, compared to someone aged between 45-54. Regarding income, the estimates show that the likelihood of buying fuel is about 1 per cent higher for high income earners than for the reference group (medium income). The estimated effect is higher in border regions, in particular nearby Belgium, than for the Netherlands as a whole. This indicates that there is a negative relationship between income and likelihood to buy fuel across the border, probably due to the higher opportunity costs for high income earners. Household size has a small but significant negative impact on the likelihood to buy fuel. The reason may be that in some households

[10] See for example Kuhnimhof, T., J. Armoogum, R. Buehler, J. Dargay, J.M. Denstadli and T. Yamamoto (2012) who show that daily mileage of females is lower than that of males in six industrialised countries.
[11] Borgoni, Ewert and Fürnkranz-Prskawetz (2002) find a negative relation between age and car use.

people share a car and the responsibility to buy fuel for it. Furthermore, we find a small but significant negative effect of urbanisation degree of the respondents' residence; people living in (semi)rural areas buy fuel more often than people in (large) cities. A possible explanation is that they have to drive longer distances for work or private reasons, while there may also be fewer alternatives in terms of public transport. Consequently, they have a higher demand for fuel and buy fuel more frequently than people living in cities. The maximum effect is 1 per cent in border provinces.

As we have daily information on consumers' purchases at the point-of-sale, we can estimate the likelihood that people buy fuel on different days in the week. The reference day is Monday. The likelihood to buy fuel is highest on Thursdays and Fridays (+ 2 per cent), followed by Saturdays (+1 per cent) and it is lowest on Sundays (-1 per cent). These effects are mostly statistically significant.

insert Table 2 about here

4.2 Assessing the impact of prices and distance to the border

Next, we extend our model by including price differentials and distance to the nearest border. Table 3 shows that the results differ per region. The likelihood that someone who lives near the Belgian border buys fuel at a domestic gas station is neither affected by the distance nor with the price difference (model 1). This even holds for people living up to 10 km from the border. The situation is different for people living nearby Germany (model 3). The likelihood that someone who lives up to 10 km from the border buys fuel at a Dutch petrol station increases by 1.1 per cent if fuel prices in Germany become 1 per cent more expensive compared to the Dutch price level. For people living between 10 – 20 km from the German border the estimated impact

is about half the size of the one for people living up to 10 km from it. However, this result is not statistically significant at the 5 per cent level.[12]

The difference in fuelling behaviour between people living nearby Belgium and people living nearby Germany suggests that the latter group balances the benefits and costs associated with travelling extra kilometres to a German gas station when deciding where to buy fuel, whereas people in the former group do not, even though the difference in fuel prices between Belgium and the Netherlands are (somewhat) larger than between Germany and the Netherlands. A possible explanation for the difference in fuelling behaviour may be that because of the increase in excise duties for diesel and LPG on 1 January 2014, people living nearby Germany faced for the first time financial gains from fuel tourism for all three types of fuel. Some of them decided to cross the border to buy fuel at a German instead of a Dutch gas station. For people living nearby Belgium this was already the case prior to the change in excise duties. The finding that the likelihood that they buy fuel domestically is not influenced by price differentials between the Netherlands and Belgium suggests that the influence of prices is only temporary. Probably, after some time, most Dutch do not seem to be willing to drive extra kilometers for cheaper petrol.[13] This explanation seems to be supported by the results for models 2 and 4, where we include dummies reflecting the time elapsed since the increase in excise duties, and their interactions with distance to the nearest border in the set of covariates. In both models 2 and 4 price differentials do not affect fuelling behaviour significantly anymore. This also holds for people living up to 10 km from the German border (model 4). What we do see is that in the first quarter of 2014 people who lived up to 10 km from the border

[12] The findings in this paper are in line with a study by the Ministerie van Financiën (Dutch Treasury) in 2014, which finds that the increase in excise duties for diesel and LPG lowered domestic fuel demand in the first quarter of 2014 in the regions up to 10 km from the border. Its results are based on information on sales volumes provided by gas stations in the Netherlands. These gas stations had a joint market of almost 50% in the gasoline market and about 1/3 of the LPG and diesel market in the period 2011 – 2014. It does not distinguish between the border region with Belgium and Germany and it does not consider the impact of the increase in excuse duties on domestic fuel demand after the first quarter of 2014.

[13] An alternative explanation may be that fuel prices in Belgium are measured less precisely, as the averages are based on a small sample of gas stations.

were less likely to buy fuel in the Netherlands than people who lived at least 30 km from the border. The estimated effect was 5.4 per cent for people living nearby Belgium, and 7.3 per cent for people living nearby Germany. The former effect is statistically significant at the 5 per cent level, while the latter is marginally significant ($p = 0.09$). The corresponding effects in the second quarter of 2014 are half the size of the ones for the first quarter and they are both insignificant.

insert Table 3 about here

These findings together point at a temporary effect of increasing excise duties on fuel tourism: just a few months after the rise consumers fuelling behaviour returns back to normal. Price differentials themselves do not seem to trigger fuel tourism by Dutch car drivers. Rietveld *et al*. (2001) provide an explanation why rising excise duties only have a temporary effect on fuel tourism: consumers tend to overestimate differentials between fuel prices in the Netherlands and abroad, as they are possibly unaware that "fuel prices in the Dutch border regions are slightly lower than the national average". Once they experience that the financial gains of fuel tourism are smaller than expected, they may conclude that the benefits do not outweigh the costs of fuel tourism. A related explanation may be that in the beginning of 2014 some of the car drivers with cars running on unleaded gasoline were initially unaware of the fact that the change in excise duties mainly affected the prices of diesel and LPG, but not of unleaded gasoline in the Netherlands. It may also be the case that people living near the border became less sensitive to price differentials in the second half of 2014 due to steadily declining fuel prices.

5. CONCLUSION

Using a detailed data set of purchase diaries, we find only limited evidence that fluctuations in cross-border fuel price differentials are relevant for Dutch consumers. For instance, we find that Dutch residents who live more than 10 km of the border are not sensitive to price differentials between Dutch gas stations and gas stations located in Belgium or Germany. In addition, we only find limited evidence that price differentials lead to cross-border fuelling by Dutch residents who live less than 10 km from the German border.

The empirical results suggest that the price differences themselves may not have been the actual trigger of cross-border fuelling. Consumers do seem to react to a substantial increase in price differentials induced by increased excise duties for LPG and diesel in January 2014. However, the impact of this change in excise duties on cross-border fuelling is estimated to be short-lived. This implies that only a small portion of the potential tax revenues leaks away to surrounding countries.

The question remains why the Dutch seem to be less inclined to buy fuel abroad than people living in other regions adjacent to regions with lower fuel prices. One reason may be that Dutch car drivers are more loyal to domestic gas stations because of saving campaigns (Rietveld et al., 2001). Also, the apparent absence of fuel tourism may be explained by the fact that commuting from the Netherlands to either Belgium or Germany is not so common (Edzes, Venhorst and Van Dijk, 2015), unlike for instance in countries adjacent to Switzerland (Banfi, *et al*., 2005) or across states within countries with different fuel tax regimes (see Leal *et al.*, 2009 or Romero-Jordán *et al*., 2013 for Spain or Manuszak and Moul, 2009 for the US).[14] It may be interesting for further research to examine the impact of commuting on fuel tourism.

[14] There are no indications that the limited impact of price differential on fuel tourism in the Netherlands is due to smaller price differentials between the Netherlands and its neighbouring countries; the price differentials mentioned in Leal *et al*., (2009) for Spain and Manuszak and Moul,(2009) for the US are of a similar magnitude. The price difference between Switzerland and its neighbouring countries is larger than between the Netherlands and either Belgium and Germany.

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Table 1. Descriptive statistics (average values)

Variable	Distance Germany	<= 10 km	10 - 20 km	20 - 30 km	>= 30 km	Distance Belgium	<= 10 km	10 - 20 km	20 - 30 km	>= 30 km	Full sample
Tanked fuel==1		0.098	0.117	0.096	0.098		0.108	0.102	0.099	0.098	0.099
Male		0.496	0.500	0.481	0.492		0.515	0.515	0.515	0.487	0.493
Age 18-24		0.063	0.066	0.066	0.061		0.055	0.059	0.064	0.062	0.062
Age 25-34		0.113	0.111	0.112	0.123		0.114	0.126	0.113	0.121	0.121
Age 35-44		0.167	0.179	0.176	0.183		0.149	0.172	0.173	0.185	0.181
Age 45-54		0.243	0.214	0.206	0.211		0.203	0.215	0.226	0.213	0.214
Age 55- 64		0.227	0.227	0.218	0.206		0.239	0.216	0.217	0.207	0.210
Age 65 and older		0.187	0.202	0.221	0.216		0.239	0.213	0.207	0.211	0.213
Household size		2.416	2.456	2.451	2.454		2.369	2.367	2.526	2.461	2.451
Education: low		0.265	0.261	0.273	0.239		0.272	0.247	0.272	0.241	0.244
Education: medium		0.404	0.397	0.377	0.383		0.381	0.380	0.378	0.387	0.386
Education: high		0.331	0.342	0.350	0.377		0.347	0.373	0.351	0.372	0.370
Urbanisation degree (1 – 5)		3.260	3.515	3.473	2.629		3.330	2.621	3.186	2.736	2.778
Income: low		0.162	0.150	0.175	0.135		0.146	0.140	0.124	0.141	0.140
Income: medium		0.393	0.374	0.398	0.372		0.378	0.377	0.365	0.375	0.375
Income: high		0.205	0.211	0.185	0.260		0.223	0.229	0.262	0.252	0.249
Province: Friesland		0.000	0.000	0.000	0.049		0.000	0.000	0.000	0.049	0.040
Province: Groningen		0.039	0.062	0.081	0.030		0.000	0.000	0.000	0.044	0.034
Province: Drenthe		0.048	0.092	0.124	0.022		0.000	0.000	0.000	0.041	0.033
Province: Overijssel		0.189	0.187	0.156	0.035		0.000	0.000	0.000	0.077	0.063
Province: Gelderland		0.237	0.376	0.297	0.065		0.000	0.000	0.000	0.136	0.110
Province: Utrecht		0.000	0.000	0.000	0.091		0.000	0.000	0.000	0.090	0.073
Province: N-Holland		0.000	0.000	0.000	0.174		0.000	0.000	0.000	0.172	0.140
Province: Z-Holland		0.000	0.000	0.000	0.265		0.000	0.000	0.000	0.263	0.214
Province: Limburg		0.487	0.245	0.216	0.002		0.426	0.282	0.138	0.017	0.067
Province: N. Brabant		0.000	0.038	0.126	0.191		0.472	0.672	0.786	0.052	0.164
Province: Flevoland		0.000	0.000	0.000	0.040		0.000	0.000	0.000	0.040	0.033
Province: Zeeland		0.000	0.000	0.000	0.036		0.102	0.046	0.076	0.020	0.029
N		**2,788**	**2,439**	**1,604**	**28,532**		**1,789**	**3,083**	**1,760**	**28,731**	**35,363**

Table 2: Regressions explaining payments at domestic gas stations

	(1) Full sample	(2) Border	(3) Belgian border	(4) German border
Male	0.05**	0.06**	0.05**	0.05**
	(0.00)	(0.00)	(0.01)	(0.01)
Age 18 - 24	-0.03**	-0.02**	-0.01	-0.03**
	(0.01)	(0.01)	(0.01)	(0.01)
Age 25 - 34	0.00	0.01	0.01	0.02*
	(0.01)	(0.01)	(0.01)	(0.01)
Age 35 - 44	0.00	0.00	0.01	-0.01
	(0.00)	(0.01)	(0.01)	(0.01)
Age 55 - 64	-0.02**	-0.02**	-0.03**	-0.01
	(0.00)	(0.01)	(0.01)	(0.01)
Age 65 and over	-0.04**	-0.04**	-0.05**	-0.03**
	(0.00)	(0.01)	(0.01)	(0.01)
Education low	-0.00	-0.00	0.01	-0.01*
	(0.00)	(0.00)	(0.01)	(0.01)
Education high	-0.00	-0.00	-0.01	-0.01
	(0.00)	(0.00)	(0.01)	(0.01)
Income low	0.01*	0.01	0.01	0.00
	(0.00)	(0.01)	(0.01)	(0.01)
Income high	0.01**	0.02**	0.02**	0.01
	(0.00)	(0.01)	(0.01)	(0.01)
Household size	-0.01**	-0.01**	-0.01*	-0.01*
	(0.00)	(0.00)	(0.00)	(0.00)
Degree of urbanisation	0.00**	0.01**	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Sunday	-0.01*	-0.01*	-0.02	-0.01
	(0.00)	(0.01)	(0.01)	(0.01)
Tuesday	-0.00	-0.01	-0.01	-0.01
	(0.00)	(0.01)	(0.01)	(0.01)
Wednesday	0.00	0.01	0.01	0.01
	(0.00)	(0.01)	(0.01)	(0.01)
Thursday	0.02*	0.02*	0.00	0.03**
	(0.00)	(0.01)	(0.01)	(0.01)
Friday	0.01*	0.02*	0.01	0.02*\
	(0.00)	(0.01)	(0.01)	(0.01)
Saturday	0.01*	0.01	0.00	0.01
	(0.00)	(0.01)	(0.01)	(0.01)
Constant	0.05*	0.05*	0.07*	0.06
	(0.01)	(0.02)	(0.03)	(0.03)
Observations	60380	30198	11560	14438
R2 overall	0.01	0.02	0.02	0.02
Number individuals	35829	17953	6915	8639
Avg. obs per individual	1.7	1.7	1.7	1.7

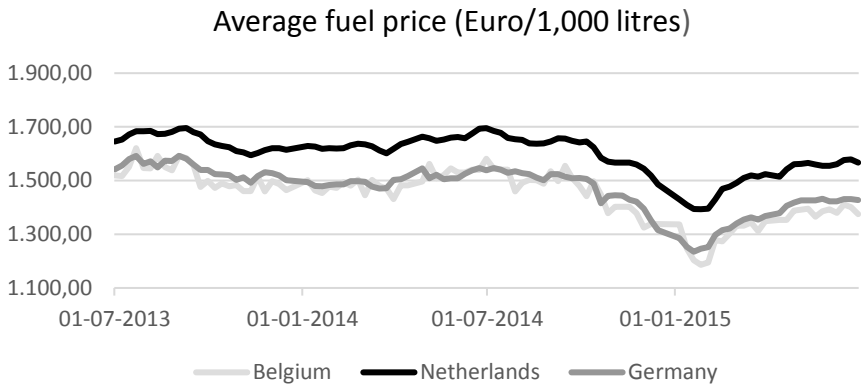
Notes: Coefficients and standard errors (in parenthesis) for random-effects regressions where the dependent variable is a binary dummy measuring whether or not an individual makes a payment at a gas station on a particular day. Column 1 has full sample results, while column 2 has results for individuals who live in one of the seven border provinces of the Netherlands. The sample period is September 2013 to June 2015. All regressions include year, week, and province dummies. */** denotes significance at the 5%/1% level.

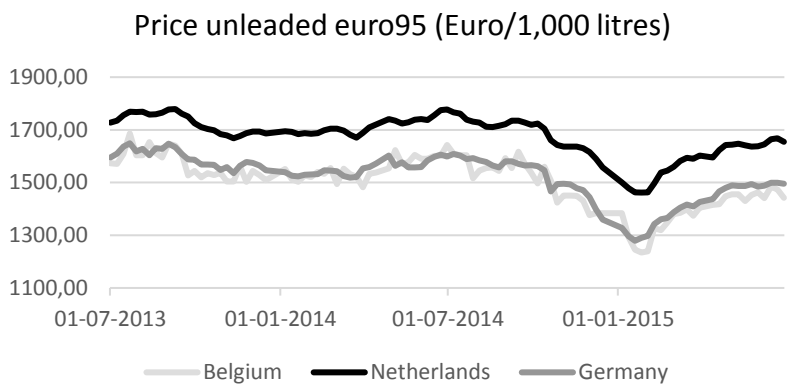
Table 3: Regressions explaining payments at domestic gas stations: prices, distances, time elapsed since increase excise duties and interactions

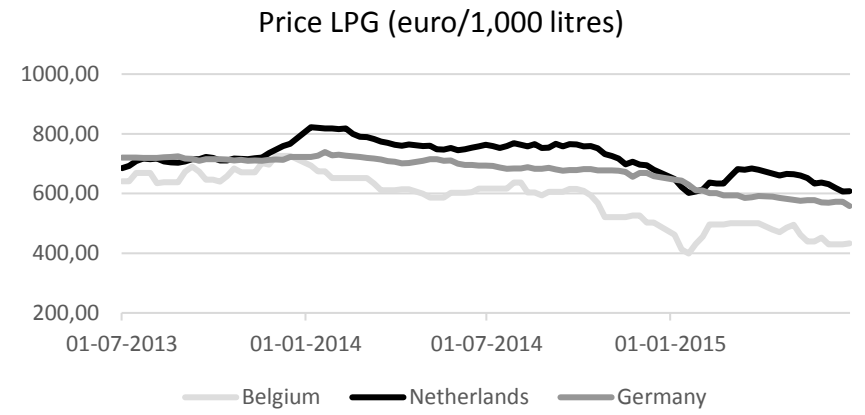
	(1) Belgian border	(2) Belgian border	(3) German border	(4) German border
Price difference	-0.001	-0.002	-0.009	-0.015
	(0.006)	(0.007)	(0.007)	(0.011)
Price difference*distance< 10km	0.004	0.001	0.011*	-0.016
	(0.006)	(0.004)	(0.005)	(0.016)
Price difference*distance 10 – 20 km	-0.005	-0.006	0.005	0.020
	(0.005)	(0.003)	(0.005)	(0.015)
Price difference*distance 20 – 30 km	-0.000	0.003	-0.004	-0.013
	(0.006)	(0.002)	(0.006)	(0.019)
Distance <10 km	0.024	0.030	0.076	-0.078
	(0.057)	(0.037)	(0.039)	(0.094)
Distance 10 – 20 km	-0.041	-0.054	0.045	0.138
	(0.049)	(0.028)	(0.040)	(0.090)
Distance 20 – 30 km	-0.008	0.019	-0.028	-0.078
	(0.053)	(0.021)	(0.046)	(0.113)
2014Q1				
< 10 km		-0.054*		-0.073
		(0.023)		(0.044)
10 – 20 km		-0.017		0.028
		(0.019)		(0.039)
20 – 30 km		0.007		-0.020
		(0.021)		(0.050)
2014Q2				
< 10 km		-0.027		-0.030
		(0.033)		(0.046)
10 – 20 km		0.049		0.033
		(0.029)		(0.041)
20 – 30 km		0.038		-0.003
		(0.031)		(0.051)
2014Q3				
< 10 km		-0.020		-0.069
		(0.028)		(0.039)
10 – 20 km		-0.012		0.015
		(0.022)		(0.036)
20 – 30 km		-0.013		-0.020
		(0.023)		(0.044)
2014Q4				
< 10 km		0.040		-0.10
		(0.040)		(0.053)
10 – 20 km		0.014		-0.000
		(0.029)		(0.048)
20 – 30 km		0.050		-0.047
		(0.031)		(0.062)
2015Q1				
< 10 km		-0.059		-0.131
		(0.034)		(0.073)
10 – 20 km		-0.015		0.096
		(0.031)		(0.070)
20 – 30 km		0.012		-0.036
		(0.030)		(0.086)
2015Q2				
< 10 km		-0.037		-0.059
		(0.039)		(0.058)
10 – 20 km		-0.019		0.068
		(0.033)		(0.051)
20 – 30 km		0.009		-0.030
		(0.035)		(0.062)
Observations	11109	11109	13870	13870
R^2 overall	0.02	0.02	0.02	0.02
Number individuals	6674	6674	8280	8280

Notes: Coefficients and standard errors (in parenthesis) for random-effects linear regressions where the dependent variable is a binary dummy measuring whether or not an individual makes a payment at a gas station on a particular day. The sample period is September 2013 to June 2015. We include individuals who live in one of the seven border provinces of The Netherlands. All regression include the covariates shown in Table X as well as year, week, and province dummies. The base category are respondents living further than 30 kilometres from the border. */** denotes significance at the 5%/1% level.

Figure 1: Fuel prices, by type and country







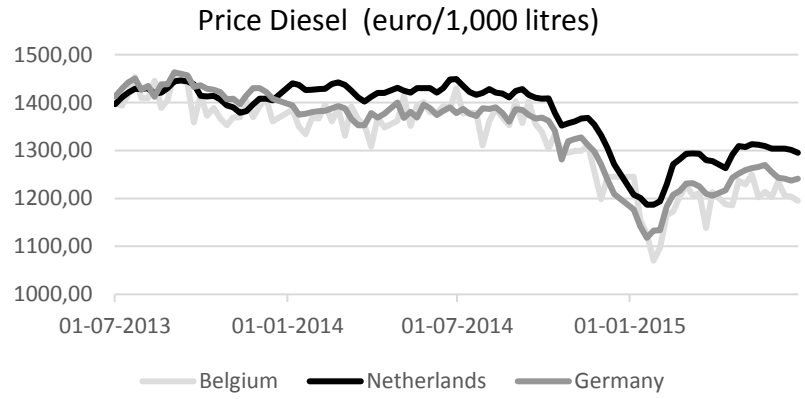
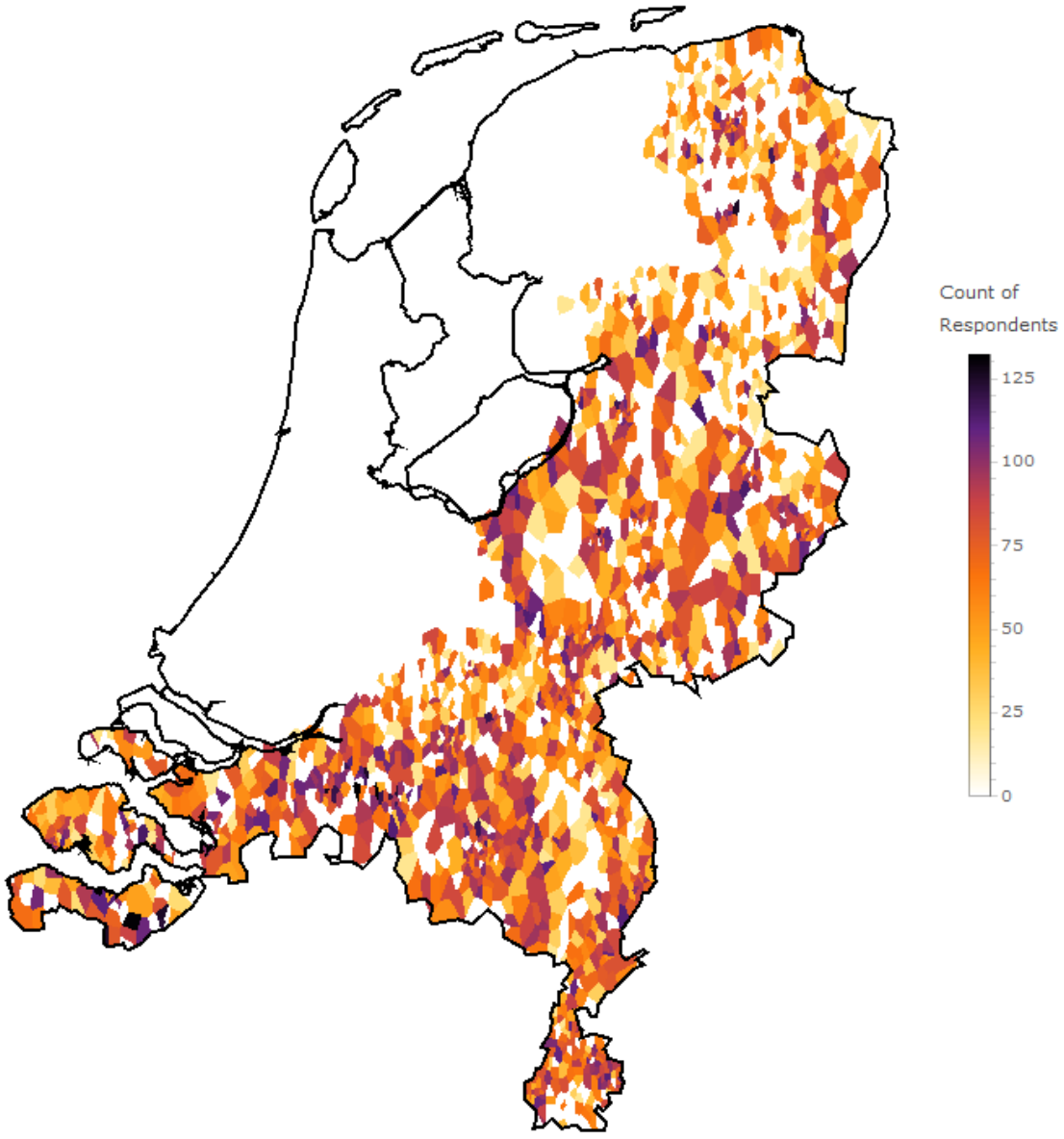
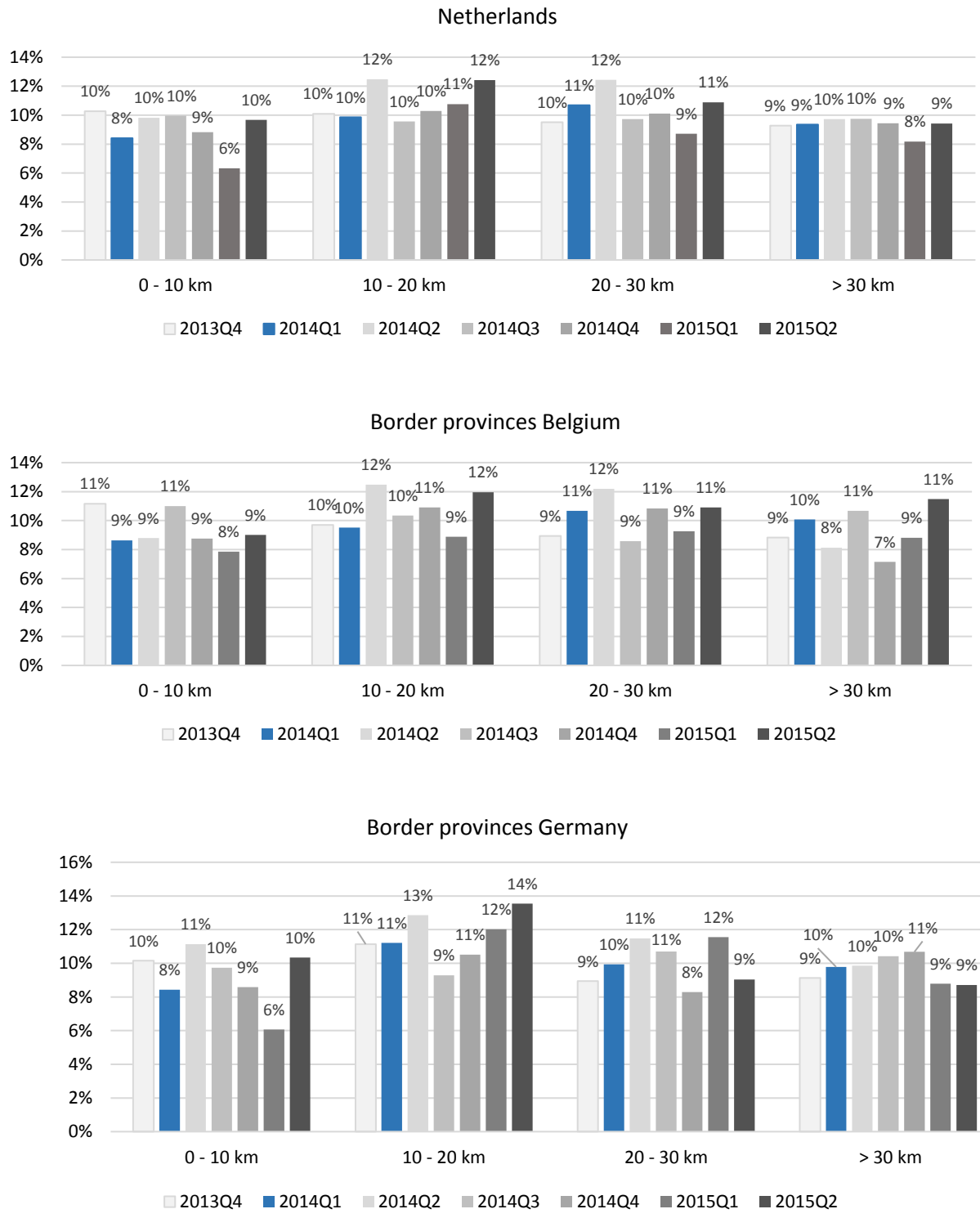


Figure 2: Place of residence of respondents in border provinces



Note: This map shows the number of respondents per 4 digit ZIP code. The sample is restricted to the seven border provinces of the Netherlands.

Figure 3: Daily likelihood to buy fuel at a domestic gas station, by distance to border



Note: Based on a data set of payment diaries, this figure shows the percentage of fuel transactions for each quarter between 2013Q4 and 2015Q2, where the sample is split on the basis of how close respondents live to the border. The top panel shows data for all respondents, the middle (bottom) panel shows transactions by respondents living close to the border with Belgium (Germany).

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