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Heterogeneity in the Tax Pass-Through to Spirit Retail Prices: Evidence from Belgium¹

Jean Hindriks² and Valerio Serse³

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Abstract

On 1st November 2015, the Belgian government increased the excise tax on alcoholic beverages. For spirits with 40% of alcohol and bottle size of 70cl, this tax change is equivalent to an amount of 2,43€ per bottle of spirits. This paper studies the impact of this tax reform on the retail price of six major brands of spirits, using a difference-in-differences method. The estimation is based on *a balanced panel of scanner data* from a major supermarket chain and uses the retail prices of the same brands sold in France by the same supermarket chain as a control group. Having information on each store geographical location, we can further test for heterogeneity in tax pass-through according to the intensity of local competition and the scope for cross-border shopping. We find that the tax was quickly passed through spirit retail prices already during the first month of tax implementation and that it was mostly over-shifted. Unlike the (nearly) uniform pricing in US retail chains, we show spatial variation in prices across stores, and we find a large heterogeneity in tax pass-through linked to variation in local competition and price elasticity of demand. Although the tax reform has considerably increased the relative price of Belgian spirits with respect to all its neighboring countries, we find a lower tax shifting only in stores bordering on Luxembourg. Which is the neighboring country with the lowest spirit prices before the alcohol tax reform. These findings have important implications for alcohol control policies as they highlight the risk that the health benefits of alcohol taxation can vary greatly across households according to where they live.

JEL No. H2, H22, H32, H71, I18

Key words: Tax pass through, scanner data, competition, cross border shopping

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1. Introduction

Various empirical studies estimate the pass-through of excise taxes to retail prices. In particular, recent works focused on tax pass-through in the market of sodas (Cawley and Frisvold, 2015; Berardi et al., 2016; Campos-Vazquez and Medina-Cortina, 2016; Grogger, 2017), cigarettes (Harding, Leibtag and Lovenheim, 2012; DeCicca, Kenkel and Liu, 2013; Xu et al., 2014) and alcoholic beverages (Carbonnier, 2013; Ally et al., 2014; Conlon and Rao, 2016; Shrestha and Markowitz, 2016). These studies mostly consist of reduced-form analysis that use price data collected from different sources during a period of tax policy change.⁴ The common strategy is to regress the price variable on a tax indicator plus a set of controls in order to isolate the causal impact of the tax on prices.

Part of this literature, however, identifies tax pass-through by means of a *“difference”* estimator. That is, by measuring pre- versus post-tax difference in retail prices. Some of the most recent papers overcome this limitation by introducing control groups that account for the counterfactual price evolution in absence of tax policy change. This allows estimating the tax pass-through by means of a typical *“difference-in-differences”* estimator. Nevertheless, type and quality of control groups for prices tend to vary over different studies. For instance, Berardi et al. (2016), which estimates the impact of the “soda tax” on prices in France, use the price of untaxed beverages as a control group for the taxed products. The same approach is adopted by Campos-Vazquez and Medina-Cortina (2016) and Grogger (2017), which both study the pass-through of the “soda tax” implemented in Mexico in January 2014. Conversely, Harding, Leibtag and Lovenheim (2012), who analyze the pass-through of cigarette excise taxes in the United States, use as a control group the same cigarette products sold in those states that did not change their cigarette excise taxes. Similarly, Cawley and Frisvold (2017) use as a control group the price of sugar-sweetened-beverages (SSBs) in the city of San Francisco to estimate the pass-through of the tax on SSBs implemented in the neighboring city of Berkley, California.

⁴ Sources of price data can include, for instance, online price comparison services (Ally et al., 2014; Berardi et al., 2016), self-reported purchases (DeCicca, Kenkel and Liu, 2013; Xu et al., 2014), scanner data (Harding, Leibtag and Lovenheim, 2012; Conlon and Rao, 2016) or governmental agencies (Campos-Vazquez and Medina-Cortina, 2016; Grogger, 2017).

This literature generally finds that tax incidence is quite heterogeneous across products and that all three patterns of under-, over- and perfect shifting are likely to occur after the implementation of an excise tax. Such evidence highlights the complexity in designing sin taxes aimed at improving public health. As price hikes and hence economic incentives tend to differ even within the same category of taxed products, there should be a rising concern about both the substitution effect towards other taxed good and the distribution of tax incidence across different types of consumers.

Although such heterogeneity in tax pass-through can be theoretically explained by differences in price elasticities and market structure across products (Hindriks and Myles 2013), just few studies were able to test for this empirically. Harding, Leibtag and Lovenheim (2012) and Cawley and Frisvold (2017), which both dispose of price data at the store level, find that part of tax pass-through heterogeneity across stores can be explained by their proximity to states with lower tax rates. In particular, they find lower tax pass-through in stores next to the border, thus suggesting that the scope for cross-border shopping drives down the extent to which stores can raise prices after a tax hike. Campos-Vazquez and Medina-Cortina (2016), which also uses price data at the store level, find that the competitive barriers faced by each store generate significant differences in the shifting of the “soda tax” in Mexico. To assess the impact of intensity of competition on tax pass-through, they compute the number of competing retailers within a distance of 8km for each store and find tax pass-through was higher in stores having less competitors nearby.

Evidence on the tax pass-through timing also suggests that prices tend to react quickly to the introduction of excise taxes. The “soda tax” in Mexico in January 2014 was already fully reflected into soda prices during the first month of implementation (Campos-Vazquez and Medina-Cortina, 2016; Grogger, 2017). While the “soda tax” in France in January 2012 was gradually reflected into retail prices and fully shifted after six months (Berardi et al., 2016). Carbonnier (2013) reports that the increase in excise taxes on alcohol implemented in France in January 1997 was immediately fully shifted to the price of both beer and aperitif during the first month of tax hike. Similar results are found by Conlon and Rao (2016), which find that pass-through of excise taxes on distilled spirits in the U.S. usually occur within a month and are often over-shifted.

Contribution to the literature:

This work wants to contribute to the empirical literature on tax pass-through by analyzing the impact of the recent alcohol tax reform in Belgium on spirit retail prices using *a balanced panel of supermarket scanner data* from a major group of retailers. Unlike conventional scanner average price data used in the literature (e.g; Nielsen measured prices), we use more detailed data on posted price from this major supermarket chain. The advantage of using posted prices is that they are not conditional on purchase and thus less sensitive to local and cyclical shocks (Coibion et al., 2015). Posted prices are not dependent neither on measurement errors due to loyalty cards (Einav et al., 2010). Although posted price data are only observed for all the retailers of the same supermarket chain, this group possesses a significant market share (about one third) and is publicly committed to match prices of local competitors (price matching strategy). Hence, their price can be considered as representative of the general price evolution in the market. Furthermore, as this group is also present in France, price data for the exact same products in France (not submitted to the tax change) can be used as a control group. The rich nature of the dataset allows testing for and explaining spatial heterogeneity in tax pass-through over Belgium. Having information on both proximity to the border and the number of competitors for each store, this work provides new evidence on the impact of the scope for cross-border shopping and the intensity of competition on the pass-through of alcohol excise taxes. Furthermore, as price data are collected over several months, this study also checks for the evolution of the tax pass-through over each month after the tax hike and tests whether the observed heterogeneity in price hikes is permanent or just temporary. The spatial dispersion in posted prices and in the tax pass-through contrasts with the recent empirical study on uniform pricing in US retail chains based on the Nielsen price measure (see Della Vigna and Gentzkow, 2017). The difference may result from the uniform mark-up rule regulation used in the US (Miravete et al., 2017).

The tax reform: On 1st November 2015, the Belgian government increased the excise tax on alcoholic beverages. The tax increase was however different across alcohol types. For instance, the taxes on beer and wine have increased by 8.5% and 31% respectively. Nevertheless, the strongest tax increase was for the category of spirits, which is also the category that was taxed most heavily before the tax reform. From 2.127,68 €/hl per % alcohol to 2.992,79 €/hl per % alcohol. That is, an increase of 41% in excise tax.

Considering a standard bottle of 70 cl with 40°C, this tax change amounts to an extra tax of 2,43€ per bottle. The magnitude of this tax increase provides a unique opportunity to estimate the tax-pass-through of spirits via scanner data across local retailers on the Belgian market, and to focus on spatial heterogeneity controlling for different supply and demand-side factors. As a prelude to the empirical analysis, we first provide a brief account of the theory on the tax pass-through and how it relates to market structure and the shape of the demand.

2. Theoretical Framework

The basic theory on tax incidence in industrial organization is about estimating the changes in prices and profits resulting from a tax (Hindriks and Myles, 2013). Let us denote the excise tax t and the producer price $p(t)$, then the consumer price is $q(t) = p(t) + t$. In our context of supermarket transactions, the producer should be understood as the retailer. In the perfect competition case, the tax incidence is very simple. The tax shifts the supply curve vertically upward by the amount of the tax. The incidence of the tax on prices is $q'(t) = p'(t) + 1$ where $q'(t)$ and $p'(t)$ are the tax derivative of the consumer and producer prices. The extent to which consumer price rises is determined by the elasticities of the supply and demand curves. If the demand is inelastic, $q'(t) = 1$ and thus $p'(t) = 0$, that is consumer price will rise by the exact amount of the tax and producer price is unchanged. We have perfect tax shifting. In all other cases the consumer price increases to a lesser extent than the amount of the tax $q'(t) < 1$, and the producer price decreases $p'(t) < 0$. The tax is shifted in part to the consumer and in part to the producer as a function of the elasticities of supply and demand. In this general case we have tax under-shifting $q'(t) < 1$. Hence, with perfect competition, the full amount of the tax may be shifted to consumers but never more, and this is only possible if the demand is perfectly inelastic.

Under imperfect competition, tax incidence is different and tax over-shifting becomes possible. This possibility depends on the shape of the demand function. To illustrate that point we need to trace the effect of the tax on the profit-maximization decisions of the imperfectly competitive firms (here retailers). To see that easily, we follow Hindriks and Myles (2013). Consider a monopoly situation with constant marginal cost. Figure 1a depicts the profit maximization of a monopoly choosing not shifting all the tax on the consumer. Indeed, the tax is shown to move the intersection between marginal cost and

marginal revenue (i.e. the profit maximization condition) from a to b with a reduction of output from y^o to y^t and consumer price rises from p to q . In this case price rises by less than the tax imposed ($q - p < t$). In contrast, Figure 1b depicts the same monopoly facing a demand function with a different shape. The demand has a concave shape: it becomes increasingly flat as quantity increases (whereas, in Figure 1a the demand has a convex shape: it becomes increasingly steep as quantity increases). In this case, the tax induces a price increase from p to q that is greater than the amount of the tax ($q - p > t$), so we have tax over-shifting. This situation could never arise in the competitive case no matter the shape of the demand curve.

Figure 1a Tax Under-Shifting under Monopoly

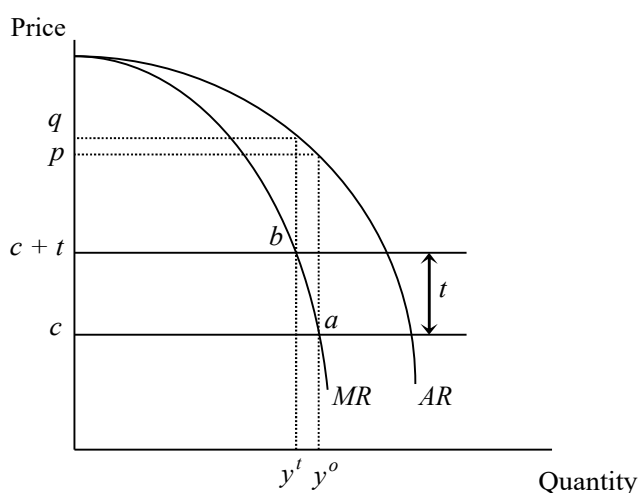
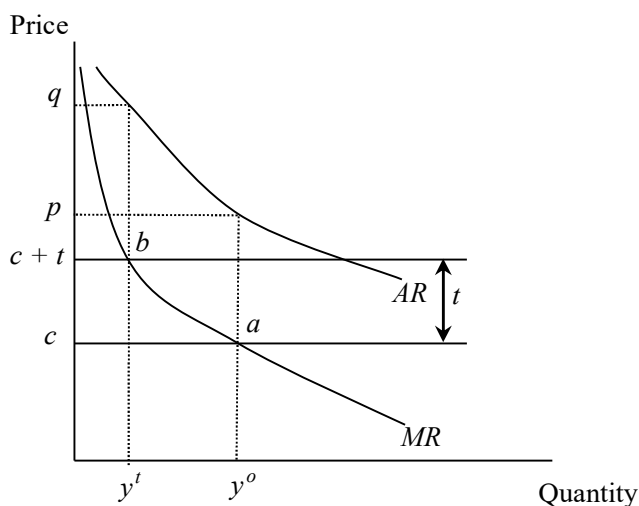


Figure 1b Tax Over-Shifting under Monopoly



To extend this result to the case of (Cournot) oligopoly, we can consider an isoelastic demand function $X = q^\varepsilon$ where $\varepsilon < 0$ is the price elasticity of demand. With a constant price elasticity, the mark up is constant $\mu^0(n) = \frac{n}{n - (\frac{1}{|\varepsilon|})}$ where n is the number of (equal-size) competing firms. When firms have different market shares ($s_i > 0$) we replace the number n by n^* (with $n^* < n$) the equal-size equivalent Herfindahl index (with $H(n) = \sum_{i=1}^n s_i^2 = \frac{1}{n^*}$). Since $|\varepsilon| > 0$, we have $\mu^0 > 1$. The equilibrium price is obtained by applying the mark up to the marginal cost-plus tax, to get $q(t) = \mu^0(n)[c + t]$. The tax incidence on price is then $q'(t) = \mu^0 > 1$. Hence there is always tax over-shifting with isoelastic demand and imperfect competition. This is true for $n = 1$ (monopoly) and $n > 1$ (oligopoly). In addition, from the expression for the markup, we have that $\mu^0(n)$ is decreasing in n , so as the intensity of competition increases (n increases) the markup decreases reducing the extent of over-shifting. At the limit as competition becomes more and more intense $\mu^0(n)$ tends to 1 and the competitive outcome of perfect tax shifting arises $q'(t) = 1$.⁵ Given this markup formulae we expect stores facing more competition and stores facing more elastic demand (e.g. lower income) to shift less of the tax on the retail price. Another surprising effect with oligopoly is that the equilibrium tax shifting can actually rise the profit level of each firm (Seade, 1985). This is easily seen with our isoelastic demand. Plugging the equilibrium price $q(t) = \mu^0(n)[c + t]$ into the demand function we obtain the output of each firm $x(t) = \frac{[\mu^0]^\varepsilon [c+t]^\varepsilon}{n}$. Plugging these equilibrium output and price levels into the profit function gives $\pi(t) = [\mu^0 - 1] \left[\frac{[\mu^0]^\varepsilon [c+t]^{\varepsilon+1}}{n} \right]$. Differentiating the profit with respect to the tax rate gives $\pi'(t) = [\varepsilon + 1][\mu^0 - 1] \left[\frac{[\mu^0]^\varepsilon [c+t]^\varepsilon}{n} \right]$. When the demand elasticity satisfies $\varepsilon + 1 > 0$ (that is if $\varepsilon > -1$) the profit is increasing with tax $\pi'(t) > 0$. This profit increase cannot arise in a monopoly since the monopoly will also find profitable to operate on the elastic part of the demand curve $\varepsilon < -1$. The intuition for the profit increasing tax in oligopoly is that the (Cournot) oligopoly involves a price that is too low relative to their joint profit maximization. Both firms would

⁵ The use of price rather than quantity as a strategic variable (as in Bertrand competition) intensifies competition and reduces profits. This means that the effective elasticity of demand is likely to be larger in magnitude than in the Cournot competition. However, if the cross-price elasticities is limited, the substitutability is limited (differentiated products) then the Cournot markup rule is likely to work. It is also likely to work in markets where competition is stable with no dynamic price wars in general. This kind of stable pricing would arise if firms have been competing for a long time and if there is some kind of price matching strategy in place. Recall that in our case, the supermarket chain under consideration is using an explicit price matching strategy based on local competition.

gain from a joint price increase. The tax provides this external incentive for a joint price increase.

The effect of cross-border shopping has been more studied in a context of tax competition between different jurisdictions that set their own tax rates on commodities. Given that purchases can be made mobile through cross-border shopping, the taxes set by each jurisdiction will be set lower in equilibrium the higher the perceived elasticity of the cross-border shopping. In our context, we do not consider the tax choices but the tax incidence on the consumer prices. We would expect that the shifting of the tax change to the consumers will be lesser the greater the scope for cross-border shopping into another jurisdiction with unchanged tax. We would also expect the elasticity of cross-border shopping to depend on the cross-border price gap before and after the reform.

3. The Data

The data used in this work are provided by a major Belgian supermarket chain with a market share of 33% in Belgium in 2017. This retail chain controls more than 400 local retailers across Belgium, France and Luxembourg. Posted price data are automatically collected by the retailer on a daily basis for every item sold in each store of the group, together with information about any price promotions and rebates. As stores are located in different areas, posted prices tend to vary considerably both within and across countries. Interestingly, given that these retailers are publicly committed to act as local price followers, their prices are matching those of other local competing retailers. Posted prices differ from the average “measured” price commonly available in scanner data (e.g. Standard Nielsen scanning data price measure in the US). The average “measured” price in a given week is the weekly ratio of sales revenue to the quantity sold. It is a quantity weighted average of posted prices. It can vary across stores and location even though the posted price is uniform. Indeed, stores facing less elastic demand (or higher income) would sell a relatively larger share at higher price, which induces a higher weight on higher prices and thus a higher average price in those stores (see Della Vigna and Gentzkow, 2017).

This work focusses on assessing the tax incidence of the tax hike in Belgium on spirits retail prices by selecting six major brands of spirit that have the unique characteristic of being sold both in Belgium (in 371 stores) and in France (in 71 stores of the same

supermarket chain). This allows performing a difference-in-differences analysis by considering the price evolution of the same brand sold in France as control group during the period of tax implementation. We therefore assume that, had the tax not been implemented, the Belgian price of each of these products would have followed the same trend as that one of the same product in France. French prices in the same supermarket chain can be considered as a good control group given that these products share the same cost components and are sold by the same retailer in these two countries that are neighbors. Interestingly, as French stores are located far away from the Belgian border, we should not expect the Belgian tax reform to impact the French prices via cross-border shopping. We restrict attention to three brands of vodka, one brand of whiskey and two brands of rum. These products differ in their alcohol content, being either 40% or 37,5%. Hence, the tax change due the tax reform should be different across these products. All products considered have the same bottle size of 70cl.

The price data consists of the monthly average of the daily price of each of these brands of spirit for each local store net of any rebates. Price records begin 9 weeks before the tax implementation and ends five months after. Figure A in the appendix displays the evolution of the average posted price of these spirits during this period for both France and Belgium.⁶ We use a set of proxies to control for different supply-side and demand-side factors that could explain spatial heterogeneity in the tax pass-through. To measure the intensity of competition faced by each store, we use a variable indicating the number of competing retailers within a driving distance of 15 minutes.⁷ These data are collected by a private company that provides contact information to suppliers about supermarkets and grocery stores located in Belgium. From their postal address, it is then possible to compute the driving distance from each store to any other retailer in the area. By having information on each store geographical location, we can also compute their distance to the nearest border in order to have a proxy for cross-border shopping. This enables checking whether those stores facing cross-border shopping responded differently to the tax change. Furthermore, to control for demand-side local heterogeneity, each store is

⁶ Given that we do not have price data before the last week of August 2015, we can only check for the common pre-treatment trend for a period of 9 weeks. As we can see from Figure A in Appendix, prices in both countries did not diverge over the 9 weeks prior the tax hike.

⁷ As this variable has some skewness due to the presence of some extreme values for few stores located in the metropolitan area of Brussels, we use the logarithmic transformation as proxy for the intensity of competition.

matched with the average GDP per capita and population density data at the Local Administrative Unit Level (NUTS 3) provided by the Eurostat. Table 1 and 2 in the appendix provide some descriptive evidence on the characteristics of products and stores.

4. The Empirical Models

In order to estimate the tax pass-through to spirits' retail prices, we perform a Difference-in-Differences analysis on six distinct products by considering the retail prices of the same products sold in France as a control group. The use of French prices for the same brand as a counterfactual can potentially control for unobserved factors, common to both France and Belgium, that could have affected the brand retail price over the period of policy implementation. In particular, three models are estimated. The model 1 focuses on the *average tax pass-through* to the retail prices of each brand. The models 2 and 3 test for *tax pass-through heterogeneity* across stores respectively without and with store fixed effect. Model 4 studies the *timing of the tax pass-through*. Model 5 estimates the *mixed spatial and time heterogeneity*.

The five models outlined above are estimated using the standard OLS procedure. A main concern in the difference-in-difference literature is that errors can be correlated across different groups of observations. In that case, assuming that errors are independent across observations can lead to an incorrect estimation of the standard errors of the treatment effects (Bertrand, Duflo and Mullainathan 2003). In our context, the potential sources of error correlation are: (i) serial correlation of errors within each store; and (ii) spatial correlation of errors across stores. The first one is standard when observing the same individual/firm over multiple time periods and it can be generated by unobserved characteristics that are constant overtime. The second one can be caused by shocks that affect stores in the same area in a similar way. This source of correlation can be very relevant in our case since stores set their prices by matching the lowest price of any competitors within a certain radius. To account for these two possible sources of error correlation, we cluster errors at the arrondissement level. As a result, we use 60 clusters for each product. This allows us to account for both serial correlation of errors within each store and shocks that could affect stores in the same area equally. Each model is estimated separately for each of the six products analyzed.

4.1 The Average Tax Pass-Through (Model 1)

The average monthly retail price of brand j in store i during month t can be expressed as follows.

$$P_{jit} = \beta_0 + \beta_1(treated)_i + \beta_2(post_reform) + \beta_3(treated_i \times post_reform) + \chi_i + \varepsilon_{it}. \quad (1)$$

Where the variable $(treated)_i$ is a dummy variable equal to 1 if the store i is located in Belgium and 0 if located in France. Its coefficient β_1 measures the pre-reform difference in prices between Belgium and France. The variable $(post_reform)$ is a dummy variable equal to 1 during the period of tax implementation (post November 2015) and 0 otherwise. Its coefficient β_2 measures the price difference between the pre-reform and after-reform period in France, which serves as a counterfactual for the price evolution in Belgium. The fourth term is the interaction of the treated group and the post-reform variables. Its coefficient β_3 captures the price increase in Belgium due to tax change and allows computing the tax pass-through rate as follows:

$$Tax\ Pass\ Through\ Rate = \frac{\Delta P_j}{\Delta tax} \times 100 = \frac{\beta_3}{\Delta tax} \times 100.$$

This work focusses on the short-run impact of the tax on retail prices, with a narrow time window going from August 2015 until March 2016. In this a way, we actually compute the difference in the average price of the product in Belgium between the three months period before the tax reform (August 2015 - October 2015) and the five months period after the tax reform (November 2015 - March 2016). This price evolution in the treated group (stores in Belgium) is then compared with the price evolution of the same product between the two periods in the control group (stores in France). A fundamental assumption of this model, however, is that nothing else a part from the tax should have affected the retail price for the same spirits' brand in Belgium and France differently in the period after the tax implementation. As the period is quite narrow, it is quite easy to check that there wasn't any major policy change in Belgium and France that was likely to have impacted the product prices differently in the two countries. Yet, given that the tax reform period includes Christmas, we include a store specific dummy variable for the month of December, χ_i , so as to capture any possible temporary price promotion that could bias the estimation of the tax pass-through coefficient downwards.

Table 3 below shows the results of the model 1, which estimates the average tax pass-through for each product. Each of the seven model estimated controls for Christmas effect in every store. Results of the model with no control for Christmas effect can be found in Table 3bis in the appendix.

Table 3

Average Tax Pass-through (Model 1)						
	Product					
	A	B	C	D	E	F
Intercept (β_0)	16,19*** (0,080)	11,68*** (0,040)	12,76*** (0,073)	14,27*** (0,055)	14,94*** (0,079)	14,68*** (0,098)
Treated (β_1)	-0,67*** (0,082)	-0,65*** (0,041)	-2,26*** (0,087)	-1,00*** (0,072)	0,68*** (0,081)	0,30*** (0,099)
Post-reform (β_2)	-0,12** (0,054)	-0,05* (0,027)	-0,20* (0,114)	-0,03 (0,068)	-0,10 (0,065)	-0,11* (0,064)
Treatment (β_3)	3,17*** (0,062)	2,47*** (0,057)	2,84*** (0,117)	2,41*** (0,074)	2,28*** (0,079)	2,95*** (0,064)
Product type	Vodka	Vodka	Vodka	Whiskey	Rum	Rum
% Alcohol	40%	37,5%	37,5%	40%	37,5%	40%
Excise Tax increase	2,43€	2,28€	2,28€	2,43€	2,28€	2,43€
% Pass-Through	130,47	108,41	124,79	99,00	100,11	121,67
Confidence Interval	125,39 - 135,56	103,53 - 113,28	114,51 - 135,06	92,88 - 105,12	93,18 - 107,03	116,41 - 126,93
Effect	<i>over-shifting</i>	<i>over-shifting</i>	<i>over-shifting</i>	<i>under-shifting</i>	<i>perfect shifting</i>	<i>over-shifting</i>
R²	0,93	0,86	0,81	0,81	0,82	0,96

Notes: *, ** and *** indicate statistical significance at the 0.10, 0.05 and 0.01 level respectively. Standard errors, clustered at the arrondissement level, are in parenthesis. From the first to the fourth line, it shows the results of the estimated coefficients. Lines five and six show the type of product and its alcohol percentage respectively. Line seven exhibits the excise tax increase for each product. While the lines eight and nine show respectively the tax pass-through rate and the confidence interval at the 5% level.

The first line of table 3 shows the intercept of the model for each product, which indicates the average product price in France in the pre-tax period. The line “Treated” shows how prices in Belgium (treated group) differed from those ones in France (control group) in the same period. The “Post-reform” line displays the price evolution in France before the reform after the reform (November 2015). This is the counterfactual scenario for the price evolution in Belgium in the absence of the tax reform. All these coefficients are negative, thus suggesting that in general spirits prices should have also declined in Belgium without the tax increase. Yet, just one coefficient out of six is statistically significant at the 5% level. The line “Treatment” shows the impact of the tax reform on the Belgian price for each product. These coefficients can be interpreted as the price increase in € induced by the tax reform. As the products considered differ in their alcohol content, the tax increase was different across products. From the tax hike specific to each product and its treatment effect coefficient, it is then possible to compute the tax pass-through rate.

As shown in table 2, the tax pass-through rate is substantially heterogeneous across products. For most of spirits, the tax was over-shifted to the retail prices. However, perfect shifting is also found for brand E and an almost perfect shifting for brand D. Such differences in pass-through are probably due to different supply-side structures and price elasticity of demand across products. The higher the intensity of competition and the price elasticity of demand, the lower should be the tax shifting to retail prices. Interestingly, the fact that for product A, B, C and F the tax was over-shifted does already suggest imperfect competition and relatively inelastic demand (as in figure 1b). Conversely, the result is less obvious for product D and E. This is because their pass-through rate, being close or equal to 100%, can be consistent either with perfect competition and inelastic demand or imperfect competition and elastic demand (such as in figure 1a).

The estimation of the same model without controlling for Christmas delivers slightly lower tax treatment effect for four products.⁸ This confirms the importance of controlling for permanent price promotion during Christmas time that could bias the treatment coefficient downwards. The treatment effect for product B is instead equal without these

⁸ The results of this model are shown in table 3bis in the appendix.

control variables, while the one of product C is slightly higher. Thus, indicating that during the month of December there were not significant price promotions for this product.

4.2 Tax Pass-Through Heterogeneity (Models 2-3)

The second model tests for pass-through heterogeneity across store's types. Theoretically, tax pass-through is a function of both market structure and demand elasticity. Therefore, accounting for spatial differences in these two factors within and across products will enable us to test for heterogeneity of tax shifting into prices. In order to account for local difference in market structure, the model contains information about the intensity of competition at the retailer level. Intuitively, one would expect both lower pre-tax prices and lower tax-pass through for highly competitive markets. As demand side factors can be important as well, the model also account for differences in consumer taste across geographical areas and socioeconomic status. Furthermore, another important factor affecting prices can be the scope for cross-border shopping. This is relevant in Belgium, a relatively small country, because a large part of the population lives in proximity to the border. This is also relevant because Belgium shares borders with several different countries (France, Luxembourg, Germany and The Netherlands) which set different alcohol taxes (Luxembourg being the least taxed of them). For this reason, the model includes information about the proximity to the border of each store in order to test for differences in price settings for stores close to the border. If cross-border shopping is an effective threat for those stores, tax shifting in border areas should be lower as the demand cross-border elasticity would be higher.

The average monthly retail price of brand j in store i during month t is expressed as:

$$\begin{aligned}
 P_{jit} = & \beta_0 + \beta_1(treated)_i + \beta_2(comp)_i + \beta_3(border)_i + \beta_4 \log(GDP)_i + \beta_5(rural)_i + \gamma_{P_i} \\
 & + \beta_7(post_reform) + \alpha_1(treated_i \times post_reform) + \\
 & + \alpha_2(comp_i \times post_reform) + \alpha_3(border_i \times post_reform) + \\
 & + \alpha_4(\log(GDP)_i \times treated_i \times post_reform) + \alpha_5(rural_i \times treated_i \times post_reform) \\
 & + \sum_P \alpha_P(\gamma_{P_i} \times treated_i \times post_reform) + \chi_i + \varepsilon_{it}.
 \end{aligned} \tag{2}$$

Where β_0 is the price intercept and $(treated)_i$ is a dummy indicating a Belgian store. γ_p are Belgian and French provinces fixed effects according to the NUTS 3 European classification. These variables control for all unobserved factors that are time invariant and specific to the given province. $(comp)_i$ is the logarithm of the number of competing retailers within 15 minutes driving distance from store i . This variable captures the impact of competition at the retailer level on the final consumer price.⁹ $(border)_i$ is a dummy variable equal to 1 if the store is located in Belgium and within 20 km distance to any border, and 0 otherwise. The variables $\log(GDP)_i$ and $(rural)_i$ are respectively the logarithm of the average GDP per capita and a dummy variable for rural areas with low population density (below 300 inhabitants per km²), which are computed for each store at the arrondissement level. They add a further dimension to price heterogeneity by controlling for differences in demand-side composition and possible differences in transportation cost. The variables $\log(GDP)_i$, $(rural)_i$ and γ_p are interacted with the treatment variable, $(treated_i \times post_reform)$, in order to test for tax pass-through heterogeneity across provinces and arrondissements. Since both number of competitors and proximity to the border are only observed for Belgian stores, there is no need to add the $(treated)_i$ variable to measure heterogeneity in treatment across these stores. It suffices to interact both the variables of $(comp)_i$ and $(border)_i$ with the $(post_reform)$ dummy variable. Hence, coefficients α_2 and α_3 measure respectively how tax pass-through changes with intensity of competition and proximity to the border. As in the model (1), χ_i captures any price variation in the month of December of any store i in order to control for possible price promotion due to Christmas time.

As price levels can vary substantially across stores, focusing on the average impact of the excise tax hike on prices can be misleading. Figure 1 to 6 in the appendix show how tax pass-through rates vary over the Belgian municipalities where the stores are located.¹⁰ As it can be seen from these maps, there is a very large spatial heterogeneity in tax pass-through for every product considered. In order to explain what drives such spatial differences, model 2 includes various proxies for different supply and demand factors

⁹ As the data just includes competitors for the Belgian stores, this variable actually captures how the difference between retail prices in Belgian stores (treated group) and the average retail price in French stores (control group) varies with the number of competing retailers.

¹⁰ The maps were made by estimating the same model as (1) but with the addition of store fixed effects and store specific treatment effect. Each store treatment coefficient is then averaged over municipalities to get the tax pass-through rates of these areas. As stores are not present in every Belgian municipality, these figures are missing for some areas (grey areas in the maps).

faced by each store analyzed. The estimation results of this model are shown below in Table 4.

Table 4

Tax Pass-Through Heterogeneity (model 2)						
	Product					
	A	B	C	D	E	F
Comp (β_2)	-0,007 (0,029)	-0,077*** (0,028)	-0,338*** (0,095)	-0,196*** (0,055)	-0,029 (0,044)	-0,050* (0,029)
Border (β_3)	-0,025** (0,012)	-0,011 (0,022)	0,028 (0,069)	0,036 (0,066)	0,027 (0,026)	-0,024 (0,016)
GDP (β_4)	-0,006 (0,104)	0,056 (0,069)	-0,026 (0,136)	-0,062 (0,108)	-0,150 (0,100)	0,097 (0,106)
Rural (β_5)	0,114* (0,059)	0,052 (0,031)	0,051 (0,079)	0,118** (0,054)	0,093* (0,050)	0,090* (0,049)
Treatment (α_1)	0,422 (1,756)	2,654 (1,621)	4,775*** (1,553)	0,726* (1,638)	-6,994*** (2,619)	2,011* (1,197)
Comp×T (α_2)	-0,124*** (0,042)	-0,304*** (0,060)	-0,153*** (0,050)	-0,229*** (0,081)	-0,259*** (0,070)	-0,002 (0,019)
Border×T (α_3)	-0,050 (0,035)	0,044 (0,075)	0,066 (0,052)	-0,041 (0,051)	-0,125* (0,072)	-0,017 (0,014)
GDP×T (α_4)	0,317* (0,163)	0,081 (0,147)	-0,140 (0,145)	0,225* (0,154)	0,946*** (0,245)	0,084 (0,112)
Rural×T (α_5)	-0,036 (0,082)	0,041 (0,078)	0,077 (0,082)	-0,028 (0,093)	0,189 (0,116)	-0,073 (0,048)
R²	0,94	0,89	0,81	0,85	0,83	0,97

Notes: *, ** and *** indicate statistical significance at the 0.10, 0.05 and 0.01 level respectively. Standard errors, clustered at the arrondissement level, are in parenthesis. Every model controls for Christmas and has province fixed effects. “T” denotes treatment variable. The table includes the heterogeneity coefficients except those capturing heterogeneity at the province level.

The first four lines of Table 4 show the estimated coefficients measuring how spirit prices in the pre-reform period vary with number of competitors, proximity to the border, GDP per capita and population density at the arrondissement level. As the first two variables are specific to Belgian stores, their coefficients measure more specifically how the

difference between the price in Belgian stores and the average French price varies with the number of competitors in the area and the proximity to the border.

The estimated coefficients for the number of competitors, β_2 , are negative for all products. Nevertheless, just three coefficients are statistically significant at the 1% level and one at the 10% level. This means that the higher the number of competing retailers within a driving distance of 15 minutes from a store, the lower the price of such stores compared to the average French price. This result is in line with the Cournot-Nash model of competition, which predicts that the higher the competitive pressure faced by firms the lower the prices. The intensity of such price competition, however, appears to vary substantially across products. For instance, considering product D, increasing the number of competitors from 20 to 60 would decrease the product price by 0,22€. The same increase in number of competitors would instead decrease the price of product B and C by 0,09€ and 0,37€ respectively.

The coefficients controlling for proximity to the border, β_3 , are not significant except for product A. This means that Belgian stores that are within a maximum distance of 20km to the closest border do not tend to set lower prices than stores located more inside the country. We obtain similar results when considering only store within a distance of either 15km or 10km to the closest border. Such result indicates that the scope for cross-border shopping did not affect product prices before the tax reform. A possible explanation for this can be the fact that the price gap with neighboring countries (notably France) was not high enough to justify a price adjustment at the border or that Belgian stores do not have perfect information about foreign prices. Another possible option could be the customer selection between cross-borders and non cross-border shoppers. The stores locate close to the border only retain the non cross-border shoppers who are likely to display less elastic demand. This effect could offset the downward pressing effect of cross-border shopping on prices.

The estimated coefficients for GDP per capita suggest that price levels do not vary across differently developed arrondissements. Yet, province fixed effects do explain part of spatial heterogeneity in prices. Hence, they are probably better capturing spatial differences in price elasticity of demand compared to differences in socioeconomic status

across arrondissements.¹¹ Population density of the arrondissements, however, seems to explain some difference in price levels for at least four spirits. Areas with a population density below 300 inhabitants per km² tend to have slightly higher prices. This could indicate either a higher cost in more remote location, due to for instance to higher transportation cost, or a more inelastic demand in these areas.

The coefficients α_1 are the “gross” treatment effect. There are significant and positive for all products except E where the coefficient is -6,983. That does not mean a negative treatment effect. Indeed, one must take into account the other interaction effects, notably the GDP interaction. For instance, the treatment increases with GDP $\alpha_4 = 0.936$ for product E. Considering the lower GDP per capita of 15,700, taking the log and multiplying by the coefficient α_4 we obtain $\log(15700) \times 0.936 = 9.04$. The treatment effect is then equal to $-6,983 + 9.04 = 2.14$ after controlling for the GDP interaction effect. For any store the GDP is higher and thus the treatment effect is greater than 2.14. Other interaction effects must also be taken into account to compute the net treatment effect.

The coefficients α_2 of the interaction effect between competition and the treatment effect are negative for all products. Five of them are significant at the 1%, while the one of product F is very close to zero and not significant. This result indicates that the intensity of competition does indeed play a role in price response to the tax increase. The higher the number of competing retailers in the area, the lower the tax pass-through to retail prices. For instance, considering product D, raising the number of competitors from 20 to 60 would reduce the impact of the tax on price by 0,25€. As for the coefficients β_2 , this finding is also in line with the standard imperfect competition model. The tax hike pushes all firms to increase their retail prices to a lesser extent if the number of competitors increases.

Proximity to the border instead doesn't seem to impact the tax shifting for most of products (coefficients α_3). The only product for which proximity to the border matters is product E, where stores close to at least 20 km from the border tend to have price reaction of nearly 0,13€ lower than other stores. Yet, this coefficient is only statistically significant at the 10% level. This can suggest that the scope of cross-border shopping does not play a significant role in the shifting of the tax on prices, even though the price gap with several

¹¹ However, province fixed effects are also controlling for differences in local cost that may arise across different provinces.

neighboring countries was reversed as a result.¹² As discussed later, the asymmetry between the competition and border effect on tax shifting can be due to the asymmetry of information on prices between Belgian and foreign (cross-border) stores. It takes more time to learn prices abroad and thus to adjust the tax shifting accordingly. Furthermore, here we assumed the “border effect” to be homogeneous across different country borders. In section 7, we relax this assumption and allow this effect to vary according to the different neighboring countries.

Lastly, differences in demographics at the arrondissement level do not seem to affect tax-pass-through substantially. Yet, for products A, D and E the tax pass through is higher in richer areas (coefficients α_4). Which can indicate that in those areas people are less sensitive to prices. The rest of the spatial heterogeneity in tax pass-through is instead captured by the α_p coefficients, which measure differences in treatment effect across provinces. The fact that tax pass-through also varies across Belgian provinces is not surprising given that consumer preferences for these products do probably vary across provinces.

To check for the robustness of the results, we further estimate model (3) by including store fixed effects to control for possible pre-reform unobserved factors that are store specific and time invariant. These variables are certainly needed to confirm or reject the hypothesis of tax pass-through heterogeneity across stores. Indeed, if the variables included in model (2) do not correctly explain pre-reform differences in prices across stores, there is a chance of mistakenly attribute post-reform price differences to the intensity of competition or proximity to the border, while instead they are the result of some unobserved store features that are constant overtime. Examples of these factors can include differences in the cost of selling the products (such as transportation costs, rents or local wages) and in price elasticity of demand.

However, as the variables used to estimate pre-reform differences across stores do not vary over the period, store fixed effects will take down the variation needed to identify

¹² Similar results are found when using other distances for proximity to the border. That is, 25km, 15km and 10km.

their coefficients ¹³. Hence, these variables must be removed from the store fixed effect model, which can be specified as follows:

$$\begin{aligned}
P_{jit} = & \beta_0 + \delta_i + \beta_2(post_reform) + \alpha_1(treated_i \times post_reform) + \\
& + \alpha_2(comp_i \times post_reform) + \alpha_3(border_i \times post_reform) + \\
& + \alpha_4(Y_i \times treated_i \times post_reform) + \alpha_5(rural_i \times treated_i \times post_reform) + \\
& + \sum_P \alpha_P(\gamma_{P_i} \times treated_i \times post_reform) + \chi_i + \varepsilon_{it}.
\end{aligned} \tag{3}$$

Where the variable δ_i represent the store fixed effects, which are dummy variables for each store i selling product j (with a slight abuse of notation we drop the index j). In total, there are as many dummy variables as the number of stores minus two, which are the reference stores for the treated (Belgium) and control (France) groups. To check whether unobserved pre-tax differences across stores drives the results of model 2, model 3 assumes the existence of store fixed effects accounting for those demand and supply factors that do not change overtime. The results of the main heterogeneity coefficients of model 3 are shown in table 5.

Table 5

Tax Pass-Through Heterogeneity (model 3) (store fixed effects)						
	Product					
Coefficients	A	B	C	D	E	F
Treatment (α_1)	1,010 (1,510)	2,605 (1,626)	6,268*** (1,290)	0,886 (1,639)	-6,170** (2,793)	2,189*** (0,611)
Comp×T (α_2)	-0,086** (0,041)	-0,292*** (0,065)	-0,119** (0,050)	-0,212** (0,089)	-0,231*** (0,078)	0,020** (0,009)
Border×T (α_3)	-0,049 (0,034)	0,042 (0,080)	0,069 (0,059)	-0,042 (0,054)	-0,125* (0,077)	-0,019 (0,013)
GDP×T (α_4)	0,246* (0,139)	0,080 (0,147)	-0,261** (0,117)	0,233 (0,154)	0,858*** (0,265)	0,058 (0,055)

¹³ These variables include number of competitors, the dummy for proximity to the border and that one for rural areas, GDP per capita of the arrondissement and province fixed effects.

Rural×T (α_5)	0,149** (0,059)	0,083 (0,088)	-0,001 (0,065)	-0,025 (0,092)	0,256** (0,117)	-0,003 (0,017)
R²	0,96	0,93	0,95	0,94	0,91	0,98

Notes: *, ** and *** indicate statistical significance at the 0.10, 0.05 and 0.01 level respectively. Standard errors, clustered at the arrondissement level, are in parenthesis. Every model control for Christmas and has store fixed effects. “T” denotes treatment variable. The table displays only the heterogeneity coefficients for the tax pass-through except for those capturing provincial heterogeneity.

The results of model 3 confirm the findings of model 2 by accounting for store fixed effects. The number of competitors tend to drive down tax pass-through for most of the product analyzed, while proximity to the border does not (except for product E). The impact of intensity of competition, however, is found to be slightly smaller compared to the model 2 and it is heterogeneous across products. Furthermore, for product F, competition seems to increase the tax pass-through but the coefficient is very close to zero. To give an idea of the magnitude of such competition effect, figure C to G in the appendix 1.A illustrate the impact of competition on tax shifting for the average store in the sample.¹⁴ As we can see from these figures, increasing the level of competition from low (15 competitors) to high (100 competitors) would lead from over-shifting to under-shifting for product B, D and E. This effect is much smaller for product A and C. For which an increasing competitive pressure would only slightly reduce tax pass-through and would not lead to under-shifting.

4.3 Timing of the Tax Pass-Through (Model 4)

The models previously presented assume that the impact of the tax on retail prices is homogeneous over the months after the tax implementation. Yet, a tax change could take some time before affecting retail prices and its impact could also vary overtime. For this reason, we estimate model 4 that accounts for lagged tax pass-through over the months after the tax change. Such model is specified as follows:

$$P_{jit} = \beta_0 + \delta_i + \sum_{t=Aug}^{Mar} \beta_{2t}(month)_t + \sum_{t=Nov}^{Mar} \beta_{3t}(treated_i \times month_t) + \chi_i + \varepsilon_{it}. \quad (4)$$

¹⁴ We exclude product F since we do not find any competition effect for this product.

Where we control for month and store fixed effects, and we include a dummy variable for the treated group for each month after the tax implementation. The treatment coefficients β_{3t} measure the price change for each month after the reform. October is taken as reference month for the pre-reform period, while changes in price during the month of December are captured by the store specific dummies χ_i , which control for Christmas effect. Table 6 below shows the results of the model estimation. Each treatment coefficient $\beta_{3,t}$ measure the absolute price increase for each month after the tax was implemented, excluding the month of December.

Table 6

Tax Pass-Through Timing (model 4)						
	Product					
	A	B	C	D	E	F
November ×T ($\beta_{3,1}$)	2,73*** (0,052)	2,65*** (0,042)	2,44*** (0,081)	2,21*** (0,064)	2,11*** (0,084)	2,66*** (0,053)
January ×T ($\beta_{3,2}$)	3,02*** (0,074)	2,51*** (0,110)	3,13*** (0,136)	2,20*** (0,104)	2,23*** (0,106)	2,90*** (0,075)
February ×T ($\beta_{3,3}$)	3,35*** (0,099)	2,27*** (0,066)	3,12*** (0,134)	2,77*** (0,117)	2,29*** (0,114)	2,94*** (0,101)
March ×T ($\beta_{3,4}$)	3,57*** (0,108)	2,43*** (0,091)	2,64*** (0,207)	2,41*** (0,094)	2,49*** (0,113)	3,32*** (0,059)
R²	0,98	0,94	0,96	0,95	0,92	0,99

Notes: *, ** and *** indicate statistical significance at the 0.10, 0.05 and 0.01 level respectively. Standard errors, clustered at the arrondissement level, are in parenthesis. Every model controls for Christmas and has month fixed effects. The table just displays the coefficients for the lagged treatment effects.

As shown in table 6, all coefficients for each product are statistically significant at the 1% level and vary overtime. This means that tax pass-through changed over the five months after the tax reform. However, the coefficients for the month of November also indicate that the reform was quickly shifted into retail prices for all brands. Figure B in the appendix shows graphically the evolution of the tax pass-through rate in the five months period after the reform. As the model controls for Christmas, the graph omits the pass-through rate for the month of December. For products A, B, C and F the tax was immediately over-shifted into their prices already during the first month of the tax

reform. While for products D and E it was under-shifted but with a pass-through rate around 90%. After the first month, the tax pass-through generally followed a positive trend for most of the spirits, to the exception of product B. From February 2016 on, the tax was either over-shifted or perfectly shifted into the price of every product.

Table 7 below shows how tax pass-through rate have changed between the first and the fifth month of tax reform. As the impact of the tax on prices was not constant over the months after the tax implementation, model 4 reaches a slightly different conclusion than model 1 (average pass through). According to model 1, the tax reform was perfectly shifted on average to the price of E. Yet, accounting for lagged effects shows that the price of this product, just like all others, has progressively been adapted over the months following the policy change. The tax reform was initially under-shifted and then five months later the tax reform was eventually over-shifted to the retail price. Similarly, the tax pass-through for products A, C and F computed five months after the reform turn out to be higher than the average pass-through computed in model 1.

Table 7

Short-run vs Long-run Tax Pass-Through (model 4)						
	Product					
	A	B	C	D	E	F
Short-run (1st month)	112,53	116,31	107,09	91,02	92,46	109,28
Confidence Interval	108,26 – 116,79	112,61 – 120,00	99,99 – 114,19	85,74 – 96,30	85,11 – 99,81	104,52 – 114,59
Effect	<i>over- shifting</i>	<i>over- shifting</i>	<i>over- shifting</i>	<i>under- shifting</i>	<i>under- shifting</i>	<i>over- shifting</i>
Long-run (5th month)	147,02	106,70	116,05	99,09	109,12	136,67
Confidence Interval	138,09 – 155,96	98,66 – 114,75	97,87 – 134,22	91,38 – 106,81	99,23 – 119,01	131,76 – 141,59
Effect	<i>over- shifting</i>	<i>over- shifting</i>	<i>over- shifting</i>	<i>under- shifting</i>	<i>over- shifting</i>	<i>over- shifting</i>
<i>Difference</i>	30,58%	-8,26%	8,36%	8,86%	18,01%	25,06%

4.4 Time and Spatial Heterogeneity in the Tax Pass-Through (Model 5)

Accounting for lagged tax pass-through can also make the results of models (2) and (3) more robust. This is because these two models, by estimating the treatment effects by averaging over the monthly prices after the reform, could confound lower pass-through in some areas (due to, for instance, higher competition or proximity to the border) with a possible lagged effect of the tax change for those stores (waiting to see how competitors react to the reform). To control for this, we also estimate model 5 testing for both spatial and time heterogeneity in tax pass-through. Such model is specified as follows:

$$\begin{aligned}
 P_{jit} = & \beta_0 + \delta_i + \sum_{t=Aug}^{Mar} \beta_{2t}(month)_t + \sum_{t=Nov}^{Mar} \alpha_{1t}(treated_i \times month_t) + \\
 & + \sum_{t=Nov}^{Mar} \alpha_{2t}(comp_i \times month_t) + \sum_{t=Nov}^{Mar} \alpha_{3t}(border_i \times month_t) + \\
 & + \sum_{t=Nov}^{Mar} \alpha_{4t}(\log(GDP)_i \times treated_i \times month_t) + \\
 & + \sum_{t=Nov}^{Mar} \alpha_{5t}(rural_i \times treated_i \times month_t) + \\
 & + \sum_{t=Nov}^{Mar} \sum_p \alpha_{pt}(\gamma_{p_i} \times treated_i \times month_t) + \chi_i + \varepsilon_{it}.
 \end{aligned} \tag{5}$$

The model above is a combination of models (3) and (4), capturing both the spatial and time heterogeneity in the pass-through. This model includes stores specific fixed effects, δ_i , and a set of month fixed effects. Each term capturing the pass-through heterogeneity across store's types is interacted with month dummies for the post-reform period in order to test for the heterogeneity persistence over the months after the reform. If the heterogeneity captured in model (3) is just the result of a slower price response to the tax for a given group of stores, then this should disappear during the following months.

So far, model 2 and 3 have shown that stores' tax shifting can vary across store's types. However, model 4 also suggests that tax shifting can vary overtime and that averaging over the months after the reform can underestimate the true tax shifting in case of a

lagged response from some stores. Therefore, model 5 seeks to understand how prices have evolved during the months after the tax reform for different types of store. The results of this model can be useful for at least two reasons. First, to explain the heterogeneity in pass-through over time found in model 4. Second, to test the possibility that the findings of model 2 and 3 about lower pass-through in stores facing more competition is driven by a delayed response of these stores to the reform. Furthermore, this model 5 allows checking whether the absence of border effect is just due to a slower reaction of those stores to the scope of cross-border shopping.

Table 8 and 9 below show respectively how intensity of competition and proximity to the border have impacted retail prices over each month after the tax reform.

Table 8

Lagged effect for number of competitors (model 5)				
Product	1st month <i>November</i>	3th month <i>January</i>	4th month <i>February</i>	5th month <i>March</i>
A	-0,061** (0,029)	-0,032* (0,041)	-0,132** (0,062)	-0,119** (0,051)
B	-0,020 (0,024)	-0,515*** (0,119)	-0,260*** (0,073)	-0,412*** (0,095)
C	-0,186*** (0,059)	-0,123* (0,072)	-0,117** (0,058)	-0,049 (0,030)
D	-0,020 (0,062)	-0,275* (0,097)	-0,300** (0,114)	-0,254** (0,106)
E	0,037 (0,058)	-0,356** (0,135)	-0,238** (0,118)	-0,365*** (0,114)
F	0,013 (0,009)	0,039 (0,021)	-0,008 (0,013)	0,036 (0,015)

Notes: *, ** and *** indicate statistical significance at the 0.10, 0.05 and 0.01 level respectively. Standard errors, clustered at the arrondissement level, are in parenthesis. Every model control for Christmas and has month fixed effects. The table just displays the heterogeneity coefficients for the lagged treatment effects related to the intensity of competition (α_{2t}). In bold, are the coefficients that are negative and significant 5 months after the reform.

As show in table 8, for most products, the intensity of competition does not affect stores' tax shifting during the first month of the reform. However, three months after the reform, tax shifting tended to be lower in more competitive areas for five of the six products

analyzed. Interestingly, such competition effect was persistent over the following two months, thus confirming that the findings of models 2 and 3 are not driven by a slower price response in more competitive areas. Yet, the coefficient for product C, although negative, is not significant during the fifth month following the reform. Thus, the initial price differences due to increasing competition tend to cancel out overtime. This could indicate either a slower reaction to the tax change of stores with higher competitive pressure or that the impact of intensity of competition on the tax pass-through for this product was just temporary and did not persist overtime. For product F, there is no competition influence on the tax shifting. Just as it was already found in models 2 and 3.

Table 9

Lagged effect for proximity to the border (model 5)				
Product	1st month <i>November</i>	3th month <i>January</i>	4th month <i>February</i>	5th month <i>March</i>
A	-0,007 (0,017)	-0,023* (0,051)	-0,132** (0,058)	-0,082* (0,043)
B	-0,054 (0,022)	-0,094 (0,128)	-0,038 (0,086)	-0,018 (0,125)
C	0,055 (0,069)	0,135** (0,087)	-0,087 (0,067)	-0,002 (0,037)
D	-0,129** (0,057)	-0,041 (0,089)	0,032 (0,076)	-0,032 (0,068)
E	0,086** (0,036)	-0,129 (0,106)	-0,243** (0,106)	-0,215* (0,116)
F	0,009 (0,011)	-0,022 (0,029)	-0,050*** (0,013)	-0,011 (0,018)

Notes: *, ** and *** indicate statistical significance at the 0.10, 0.05 and 0.01 level respectively. Standard errors, clustered at the arrondissement level, are in parenthesis. Every model control for Christmas and has month fixed effects. The table just displays the heterogeneity coefficients for the lagged treatment effects related to the proximity to the border (α_{3t}). In bold characters are the coefficients that are negative and significant at the 10% level 5 months after the reform.

As shown in table 9, the results of model 5 tend to reject the hypothesis that the lack of border effect is just due to a different timing of tax shifting for stores at the border. For most products, there is no significant differences in tax shifting over time between stores close to the border and those which are not. Just product A and E had lower tax shifting in shops at the border during fifth month after the reform. Yet such are only significant at

the 10% level. These findings suggest that stores are more sensitive to domestic than the foreign (cross-border) competition. However, since the period of analysis here is limited to five months after the reform, this may be true just in the short-run. It is indeed reasonable to think that stores have more information about Belgian competitors than foreign competitors. Hence, any strategic reaction to foreign competition may take more time to occur.

5. Alternative specification for the “border effect”

The fact that the models estimated so far did not capture any “border effect” in the tax shifting is somehow surprising given that the price gap between Belgium and any other neighboring countries have substantially increased. We would have expected a lower tax pass-through, not only in stores close to a country having lower after-tax prices, but also in those ones close to a country where prices were still higher even after the tax reform. This is because the tax hike was so high that it should have also discouraged the cross-border shopping from neighbors that usually buy their spirits in Belgian stores. This can be notably the case of Netherlands, where the price for these spirits was between 3€ and 5€ higher than Belgium before the tax reform.

As the models estimated so far reject the hypothesis of homogeneous “border effect” across different borders, we run other models that tests for the heterogeneity of the border effect across countries. In practice, we re-estimate models 3 and 5 by introducing an interaction term between the border dummy (within 20km to the border) and another dummy variable indicating the adjacent country. We find no impact when considering just those stores at the border with either France, Netherlands or Germany (where prices were respectively comparable, higher or slightly lower before the reform), but we do find a lower tax-pass-through for those stores located within 20km to the Luxembourg border (where prices were much lower before the reform). Yet, this is not the case for all products.

Table 10 below shows the net effect on the after-tax price of being a store close to at least 20km to the Luxembourg border for each of the product considered. We display both the results of the time-average effect (model 3) and the lagged effect five months after the tax reform (model 5) to check for its persistency over time. The coefficients can be interpreted as the difference in the after-tax price in euro due to the proximity to

Luxembourg, once having controlled for differences in demand and supply-side factors over stores.

Table 10

Effect for proximity to Luxembourg						
	Product					
	A	B	C	D	E	F
Average Effect (model 3)	0,02 (0,04)	-0,75*** (0,26)	0,19 (0,12)	-0,05 (0,10)	-0,52** (0,23)	-0,65** (0,30)
Effect after 5th month (model 5)	0,00 (0,05)	-0,90** (0,37)	0,64*** (0,235)	0,06 (0,24)	-0,81* (0,44)	-0,80** (0,38)

Notes: *, ** and *** indicate statistical significance at the 0.10, 0.05 and 0.01 level respectively. Standard errors, clustered at the arrondissement level, are in parenthesis.

The scope for cross-border shopping seems to reduce considerably after-tax prices for just three of the product considered (B, E and F). With this effect being persistent after 5 months of tax implementation. Conversely, no effect is found for products A and D,¹⁵ while we see a positive difference for product C but only during the fifth month of tax hike.¹⁶ Luxembourg was the neighboring country with the lowest spirit prices before the tax reform in Belgium. The price gap for the exact same bottles of spirit was on average of 4€ lower before the tax hike. This means that the magnitude of the price gap with a neighboring country does reduce tax shifting, but only for those stores close to a country exhibiting much lower prices before the tax implementation. This is confirming the standard view that the scope for cross-border shopping increases with the price differential between two neighboring countries. Yet, the absence of “border effect” for stores close to either France (where spirit prices were only 0.5€ higher before the tax) or Germany (where spirit prices were around 1€ lower before the tax) could also suggest a lack of information by stores and consumers about foreign prices. This is because the price differential between Belgium and these two countries after the tax implementation

¹⁵ Nevertheless, we should notice that there is only one store within 20km distance from Luxembourg that sell product A.

¹⁶ This effect is however just present during the month of March 2015 and it is probably due to some temporary price promotion that occurred during that month in other shops. Indeed, once we control for this, such effect disappears.

was not trivial and hence it should have encouraged Belgian consumers to shop their spirits abroad. Given that price differential with Luxemburg was instead already high before the tax reform, both stores and consumers were probably more aware of lower spirit prices in that country.

6. Robustness checks on the competition effect

We run few robustness checks in order to validate our analysis. A possible concern about the estimates on the impact of the intensity of competition on tax pass-through can be the lack of a proper counterfactual for stores facing a similar degree of competitive pressure. As we do not have data about the number of competitors for each French store, we did not formally check whether spirit prices in France have also declined by more in highly competitive areas after the tax reform. If that is the case, we cannot confirm the hypothesis that tax pass-through declines with competitive pressure as lower prices in highly competitive areas might be the result of some unobserved shock that is correlated with the tax reform. In order to rule out this possibility, we run another model where we use population density at the arrondissement level as a proxy for intensity of competition. In such a way, we can control for the evolution of spirit prices after the tax reform in control stores with different population density (competitive pressure). The assumption here is that competitive pressure for French stores increases with population density. The use of such variable to measure competitive pressure can be justified by at least two reasons. First, supermarkets have to locate in areas with a large consumer base in order to maximize their revenues. Hence, it is reasonable to expect higher competitive pressure in more densely populated areas. Second, in our sample, population density at the arrondissement level is highly correlated with the number of competitors for each Belgian store. This is the case even after controlling for local GDP. The complete specification of this model together with its results can be found in the appendix 3.A. Overall, the model indicates that tax pass-through decreases with population density for all the products analyzed, although their significance varies over spirits. Importantly, these results reject the hypothesis that spirit prices in control stores with higher population density decreased in the after tax period. Furthermore, for most of products, we do not find any heterogeneity in the price evolution of control stores in the after tax period across different GDP levels. Hence, this suggests that spatial heterogeneity in spirit prices did not increase in the control group after the tax reform, as it was the case for Belgium.

To confirm this result, we can also check the evolution of price dispersion over French stores before and after the tax reform. In order to do that, we firstly compute the average product price for each French store both before and after the tax reform and then compute their standard deviation from the average French price in each of those two periods. We repeat the same procedure for Belgian stores so that we can compare how spatial price dispersion changed during the post-reform period for both treated and control groups. The results of this analysis are shown in Table 11bis in the Appendix 3.A. As we can see from this table, spatial price dispersion in Belgium did significantly increase after the tax reform while it stayed constant during the same period in France.¹⁷ This suggests that heterogeneity in the treatment effect over different competitive areas is not due to an unobserved shock in spirit prices but due to the tax hike.

We run also another robustness check by estimating the same models using the highest daily price of the month (peak price) for each store instead of the monthly average of the daily price. This exercise allows controlling for temporary price promotion that can occur in different stores over different periods than Christmas. As Cawley and Frisvold (2017), we did not control for that in the main model since we are more interested in the actual price that consumer paid over different stores. Yet, the main concern is that temporary promotions can occur in different period for France and Belgium. Furthermore, they can be correlated with the intensity of competition. Running the models with peak price instead of monthly average price, we obtain very similar results with the difference that treatment effect get slightly higher, thus further strengthening the finding that the tax was over shifted to spirit prices. Furthermore, by adjusting for temporary price promotion, we find the competition effect for product C to be persistent until the last month of price observation. Hence, the impact of competition on tax pass-through is not temporary but persistent.

7. Impact on the volume of sales

The models gave a measure of how the tax reform was shifted to spirit retail prices. As tax shifting was substantially heterogeneous over the country, the demand response to such

¹⁷ In particular, price dispersion in Belgium significantly increased for each product except for product F. For which we did not find in fact any competition effect. Conversely, there is not any significant change in price dispersion in France except for product A. For which we instead find a slight decline in price dispersion over the post reform period.

policy may also vary over different store locations. Furthermore, the absence of lower tax pass-through in areas close to the border could also suggest that a great part of domestic sales could have been lost due to cross-border shopping.

In order to test these hypotheses, this section presents some descriptive statistics about the evolution of spirits sale over the period after the tax implementation. Compared to the analysis made on prices, the group of retailers in France cannot be considered as a relevant control group for the evolution of Belgian sales in the absence of the reform. This is because this group of retailers is a much smaller player in the French market than in the Belgian market and consumer preferences might differ in the two countries. Conversely, a product sold by the same supermarket chain in both countries is very likely to share the same cost components and hence any cost shock should be reflected into retail prices similarly. As the demand for spirits tend to be highly seasonal, spirit sales the year after the tax reform can be compared with those of the same Belgian stores the year before the reform.

Table 12 below shows the percentage change with respect to the previous year in the volume of overall sales of the six products analyzed in the Belgian stores of this group of retailers. The table also shows the yearly percentage change in the volume of sales for every Belgian province and for the country of Luxemburg.¹⁸ This exercise can give an idea of whether sales have evolved differently over provinces after the reform and whether part of sales have been shifted across the border (in Luxemburg notably with the lowest spirit prices). As the tax change was announced in October 2015, one month before the reform, this month is excluded from the computation, as there is scope for stockpiling before the reform (anticipating the tax hike). To test for this stockpiling effect, the sales in October 2015 are compared to those in October 2014. The results of this computation is shown in the last column of table 12.

Table 12

Evolution of Spirit Sales (all brands in volume)

¹⁸ Data on sales in Luxemburg are available since this group of retailers is also present with few stores in this country.

Area	Δ year 1 (nov2015- sep2016)	Δ year 2 (nov2016- sept2017)	Stockpiling
Belgium (Total)	-8,51%	-9,25%	+76,86%
Brussels Capital Region	-18,51%	-21,93%	+48,65%
Walloon Brabant	-1,65%	-9,93%	+56,81%
Flemish Brabant	+4,91%	-5,19%	+93,61%
Antwerp	+1,95%	-8,30%	+114,09%
Limburg	-5,19%	-11,82%	+90,88%
Liège	-18,60%	-15,82%	+4,57%
Namur	-12,82%	-4,01%	+55,51%
Hainaut	-21,33%	-9,23%	+11,19%
Luxembourg (province)	-10,95%	-6,68%	+42,13%
West Flanders	+1,58%	-2,22%	+128,26%
East Flanders	-1,20%	-4,55%	+138,09%
Grand Duchy of Luxembourg	+61,94%	+72,06%	na

Notes: the first two columns show the percentage change in spirit sales with respect to the previous year. The pre-reform year is the period going from November 2014 to September 2015. The last column on stockpiling shows the percentage change in spirit sales in October 2015 compared to October 2014.

Overall, during first period of tax implementation (November 2015 – September 2016), spirit sales have declined by 8,51% with respect to the same period in the previous year. Similarly, sales have continued to drop the year afterwards by 9,25%. Interestingly, by comparing sales in the month of October 2015 with those ones in October 2014, it is observed an increase of nearly 80%. Which strongly suggests evidence of spirit stockpiling in response to the tax announcement in October 2015. This highlights the risk of ignoring stockpiling behavior when performing ex-ante evaluation of taxes on storable goods, as this can lead to an overestimation of the resulting reduction in consumer

demand (Wang, 2015). Table 12 also provides an overview of how demand has changed in the different Belgian provinces. As shown in this table, the reduction in demand was very heterogeneous across provinces. This is not extremely surprising as consumer elasticity of demand can vary over different geographical areas. Furthermore, as shown earlier, the tax shifting was very different across stores.

As this analysis just considers sales of one group of retailers, it is not sure whether the tax reform has led some domestic consumer buying spirits in other Belgian retailers to switch their spirit purchases over this group of stores (change in market share). Some evidence of this can be found by looking at the evolution of spirit sales in the provinces of Flemish Brabant, Antwerp and West Flanders during the first year of the reform. In these provinces, stockpiling was greater than average and demand had slightly increased compared to the previous year. Thus, suggesting a possible shift of consumers who previously purchased spirits in other retailers. This fact, however, can also suggest a lack of alternative as compared to the rest of the country. Indeed, all these provinces are located in the north of the country and share a border with the only foreign country with similar spirit prices after the tax reform.

Conversely, provinces located more in the south, which share borders with countries having lower spirit prices (Luxembourg), experienced both a greater drop in demand and a lower spirit stockpiling compared to the average figures. This can suggest that consumers that have access to this cross-border alternative started purchasing spirits in Luxembourg after the tax reform. Evidence on the evolution of sales in Luxembourg clearly supports this hypothesis. One year after the reform, the sales of spirits in stores located in Luxembourg have increased by nearly 62% with respect to the previous year. Furthermore, the second year after the reform those sales have continued rising by 72% as compared to year 1.

Importantly, as this analysis does not control for any confounding factors that might have occurred during the years after the reform and uses data from just one group of retailers, these figures cannot be interpreted as the causal impact of this reform on the volume of sales. Yet, these statistics can provide some evidence of spirit stockpiling and highlight the heterogeneous changes in the volume of sales across provinces after the tax reform. Moreover, these figures also show a strong positive spillover of the tax increase on the

volume of sales in the neighboring country with the lowest alcohol prices. Thus supporting the scope for cross-border shopping of spirits in favor of Luxembourg.

8. Conclusions

The results of this analysis have shown that the recent alcohol tax increase implemented in Belgium was mostly over-shifted to the retail price of six major brands of spirit. These products reacted very quickly to the tax reform by adapting their retail prices already during the first month of tax implementation. Results also indicate that the tax pass-through was substantially heterogeneous both across spirits and over the country. In particular, intensity of competition is found to be one of the main drivers of spatial heterogeneity. The higher the number of retailers in the area, the lower the tax pass-through. Conversely, proximity to the French, Dutch and German border does not seem to affect the tax shifting over the first five months of tax implementation. Although the tax reform have considerably increased the relative price of Belgian spirits with respect to these countries. Yet, we do find a quite lower tax pass-through for some products in stores bordering on Luxembourg. Which is the only country having much lower spirit prices already before the alcohol tax reform. This indicates that, at least in the short-run, stores tend to be more sensitive to domestic than foreign competition as long as the price gap with the neighboring country is not too large. We argue that a possible explanation to this phenomenon could be a lack of information of Belgian stores about foreign prices.

In a public health perspective, these findings suggest that the health benefits associated with this tax will have a differential impact on Belgian households according to where they live. To support this hypothesis further, we analyze the evolution of spirit sales in the stores considered and provide evidence of a strong link between the tax hike and both a heterogeneous variation of spirit demand over Belgian provinces and spirit stockpiling before the tax implementation. Furthermore, we observe a substantial rise of spirit demand in Luxembourgish stores, which suggests effective cross-border shopping of spirits by Belgian consumers.

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Appendices

1.A Figures and Tables

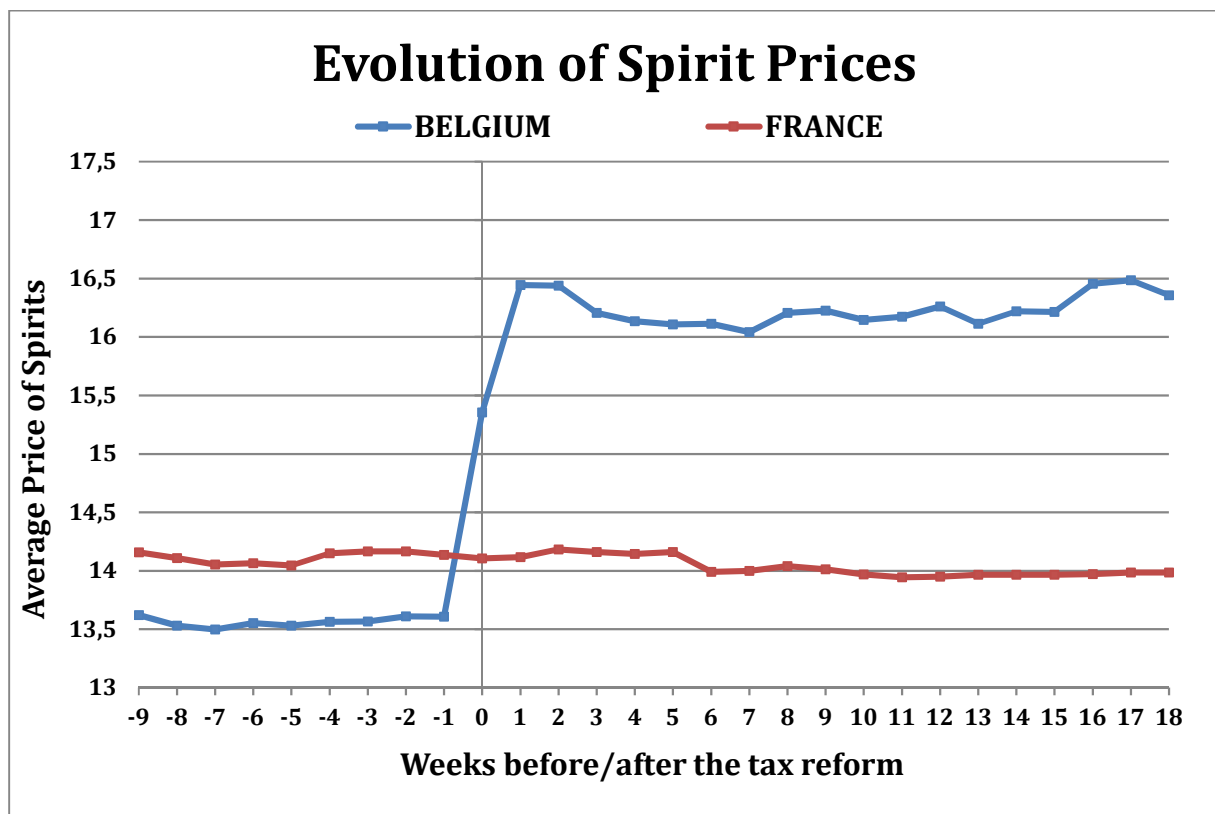
Table 1

Characteristics of products							
		Product					
		A	B	C	D	E	F
Type		Vodka	Vodka	Vodka	Whisky	Rhum	Rhum
Size		70cl	70cl	70cl	70cl	70cl	70cl
N° Obs		2960	3096	3248	3256	3240	3279
Belgium	Average Price in € (before tax)	15,53	11,02	10,50	13,27	15,62	14,98
	Average Price in € (after tax)	18,44	13,44	13,18	15,62	17,68	17,76
	N° of stores	303	318	337	336	335	335
France	Average Price in € (before tax)	16,19	11,68	12,76	14,27	14,94	14,68
	Average Price in € (after tax)	16,06	11,62	12,56	14,31	14,87	14,57
	N° of stores	67	69	69	71	70	66

Table 2

Characteristics of store locations					
		Average	Std. Dev.	Minimum	Maximum
Belgium	GDP per capita (€)	30.125,58	9365,36	15.700	63.330
	Population Density	538,45	1099,45	45,90	7.408
	N° of Competitors	51,48	43,26	3	225
	Next to the Border	45,40%	49,86	0	1
France	GDP per capita	28.36,32	5.832,27	20.400	42.500
	Population Density	431,23	1.268,48	28,90	5.638,40

Figure A



Source: authors.

Table 3bis

Average Tax Pass-through (without Christmas controls)						
	Product					
	A	B	C	D	E	F
Intercept (β_0)	16,19*** (0,076)	11,68*** (0,037)	12,76*** (0,064)	14,27*** (0,051)	14,94*** (0,075)	14,68*** (0,092)
Treated (β_1)	-0,67*** (0,079)	-0,65*** (0,039)	-2,26*** (0,082)	-1,01*** (0,067)	0,68*** (0,076)	0,30*** (0,092)
After Tax (β_2)	-0,13** (0,043)	-0,05** (0,021)	-0,20* (0,100)	-0,03 (0,066)	-0,07 (0,063)	-0,11* (0,059)
Treatment (β_3)	3,04*** (0,051)	2,47*** (0,054)	2,86*** (0,106)	2,32*** (0,060)	2,14*** (0,77)	2,89*** (0,060)
Effect	<i>over-shifting</i>	<i>over-shifting</i>	<i>over-shifting</i>	<i>under-shifting</i>	<i>under-shifting</i>	<i>over-shifting</i>

Notes: *, ** and *** indicate statistical significance at the 0.10, 0.05 and 0.01 level respectively. Standard errors, clustered at the arrondissement level, are in parenthesis.

Figure B

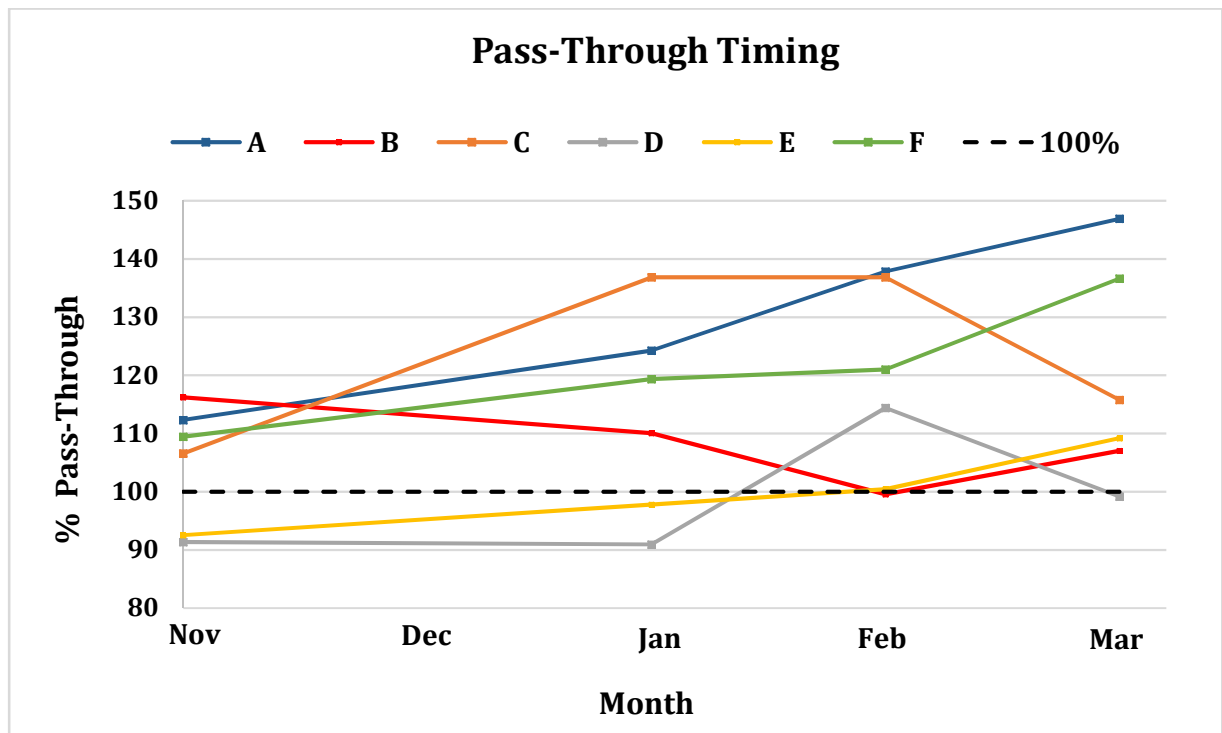
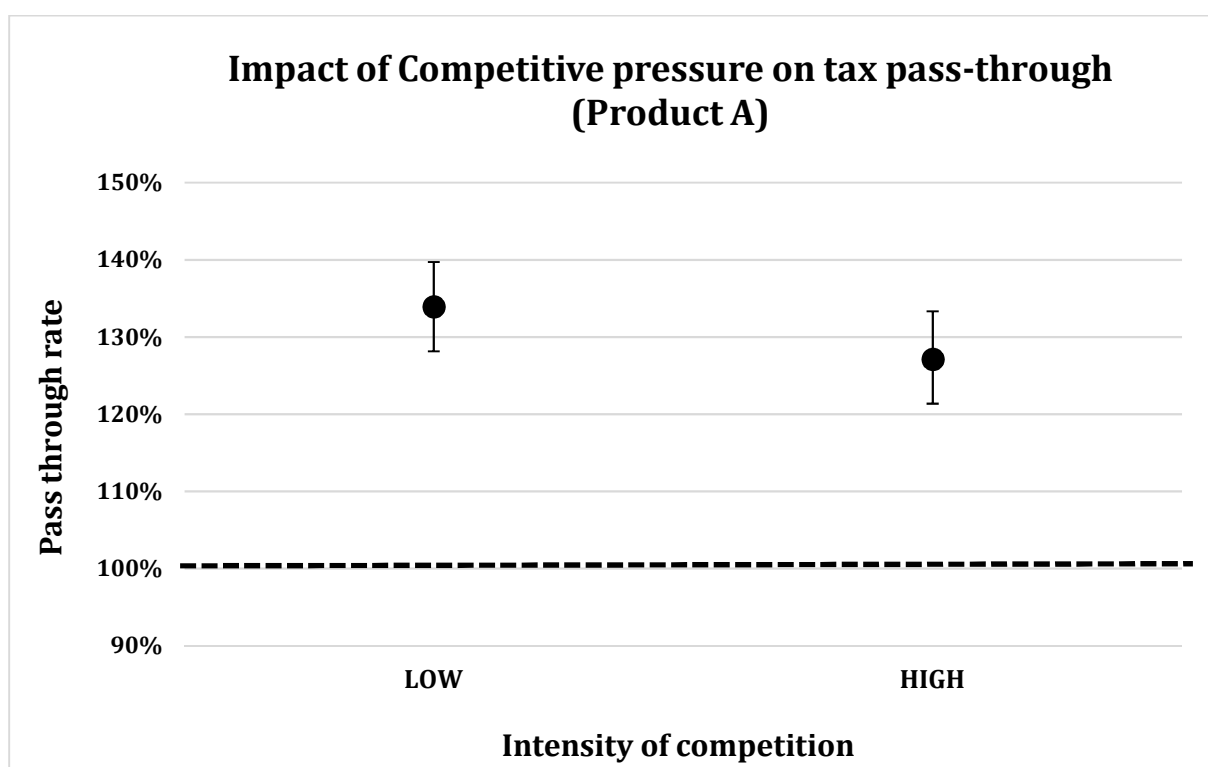


Figure C



Notes: All figures from C to G show the impact of different level of competition on the tax shifting together with their confidence interval at the 5% level. Low and high competition corresponds to 15 competitors and 100 competitors respectively. All estimates are computed for the average Belgian store in the sample.

Figure D

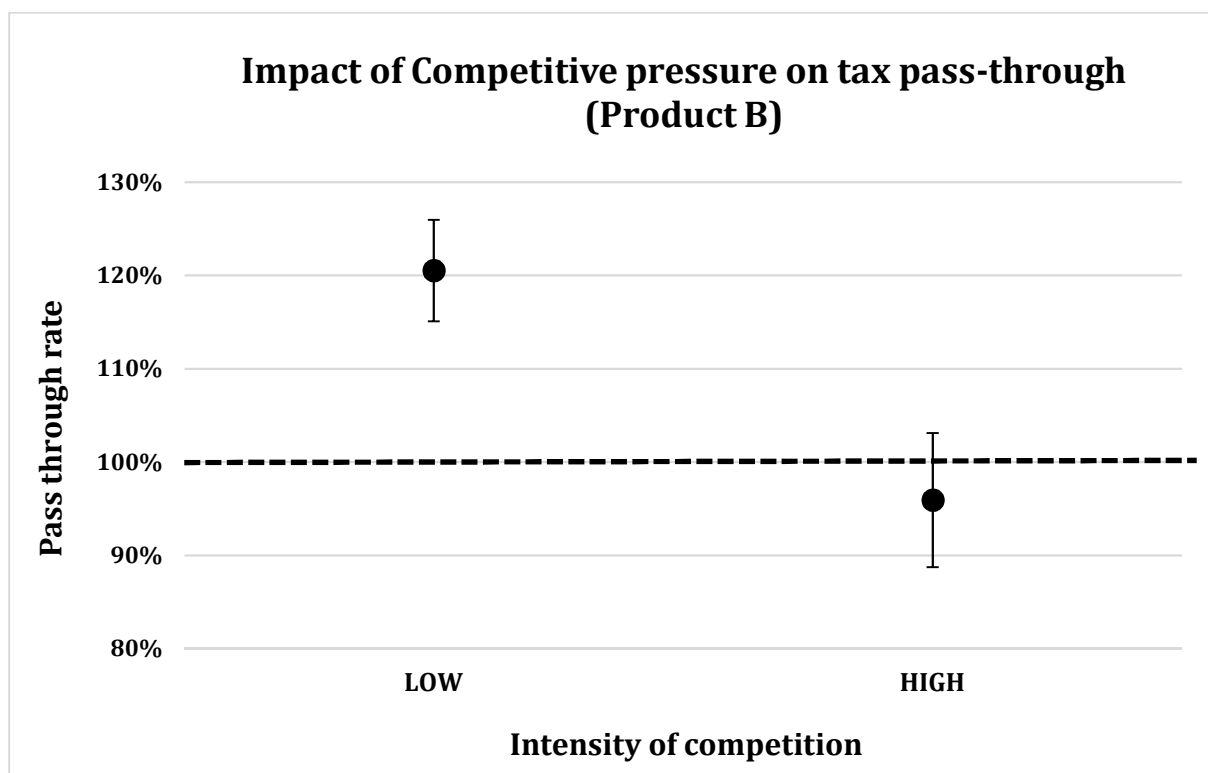


Figure E

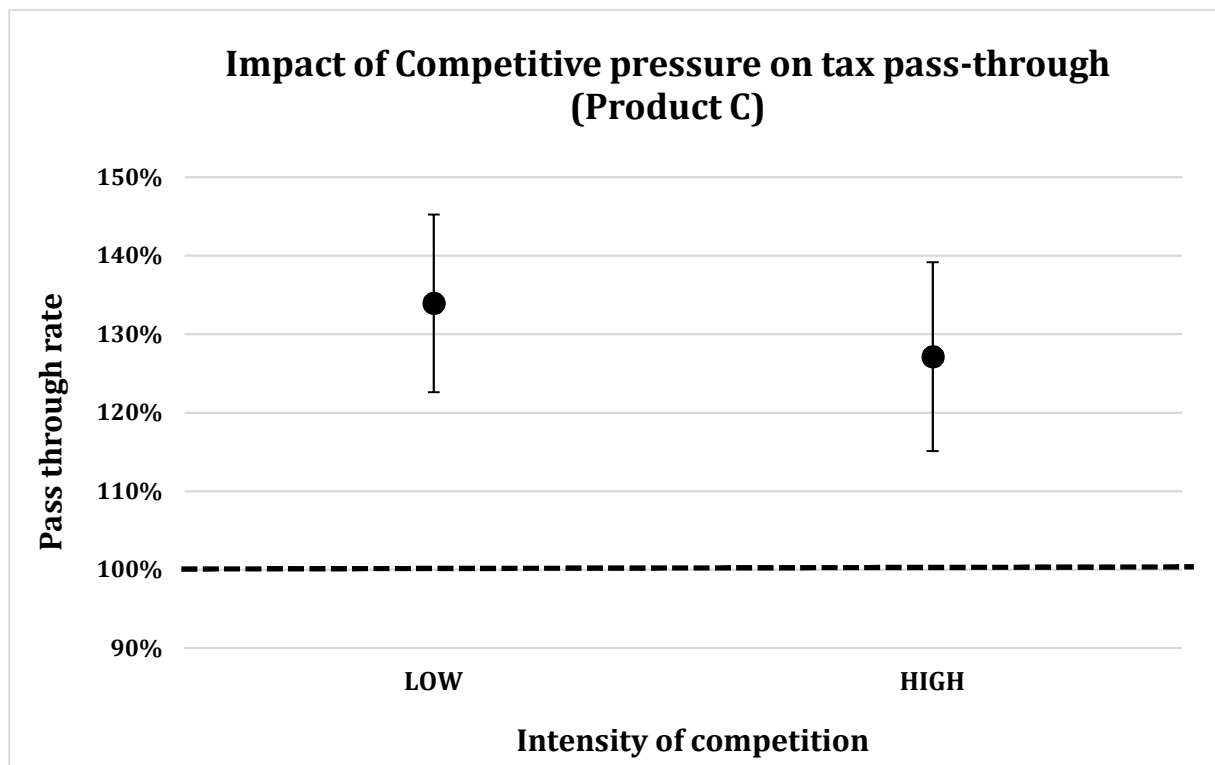


Figure F

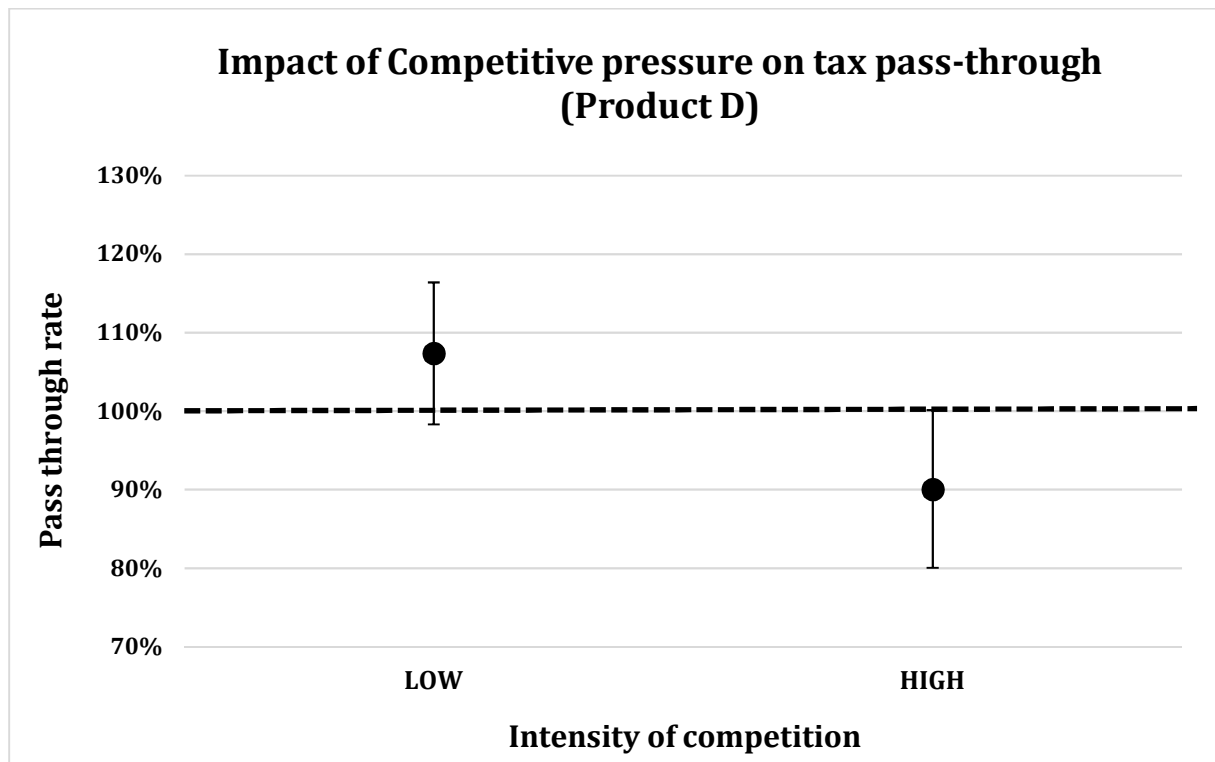
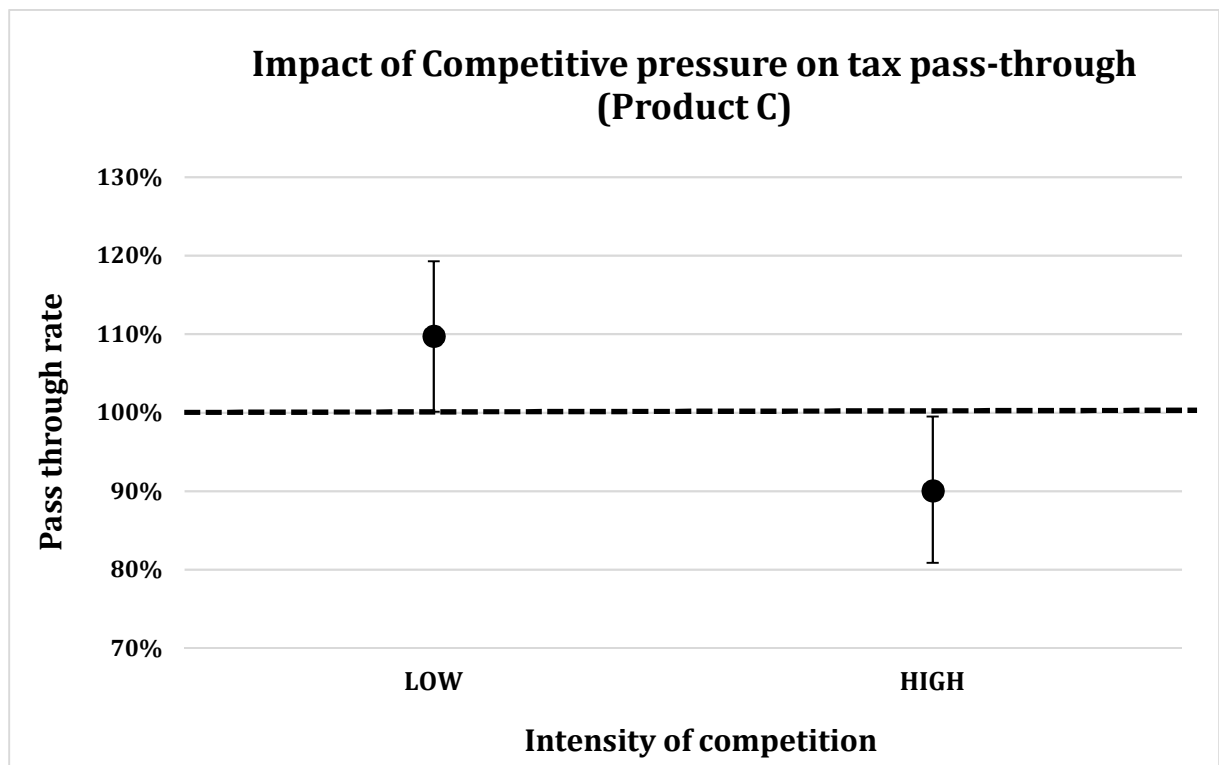
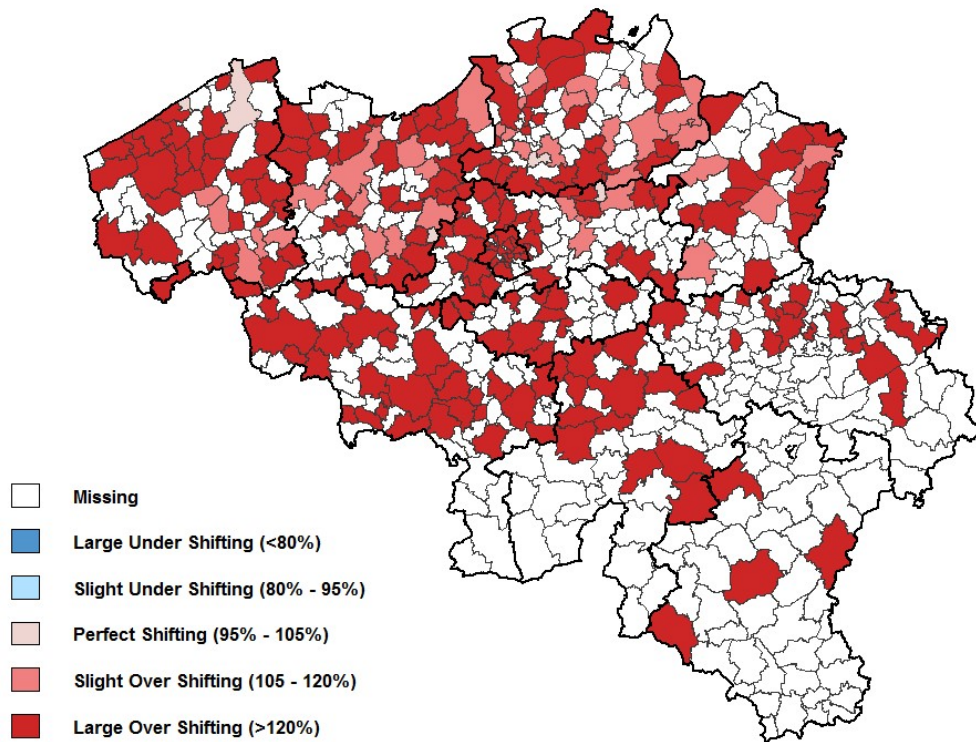


Figure G

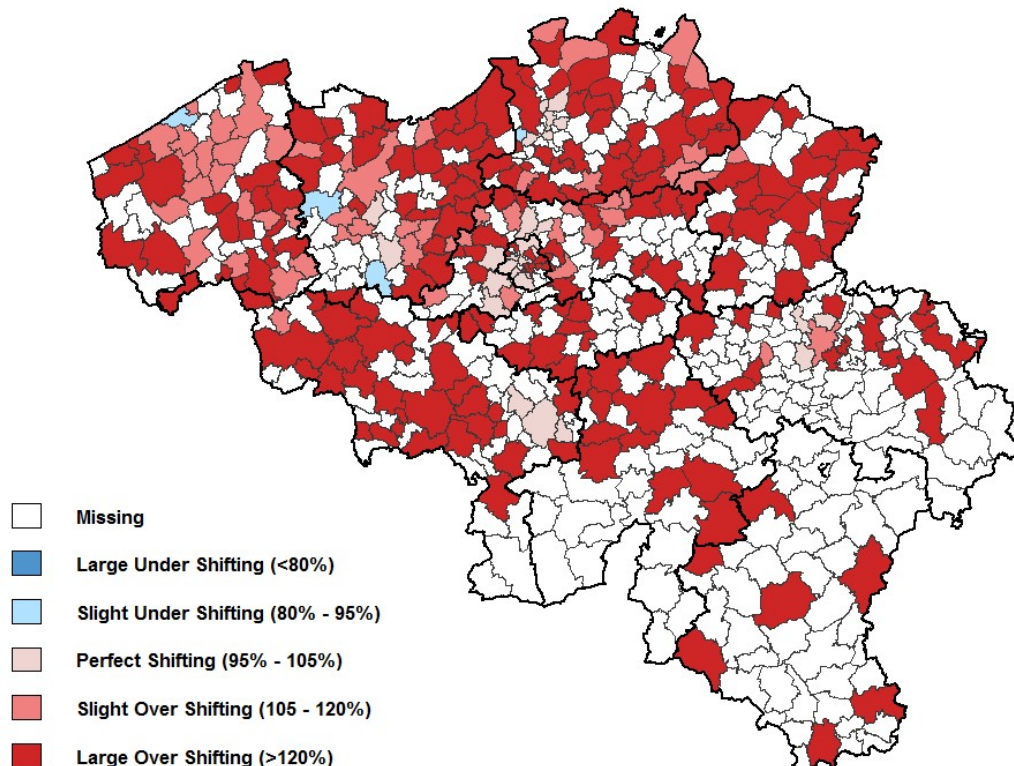
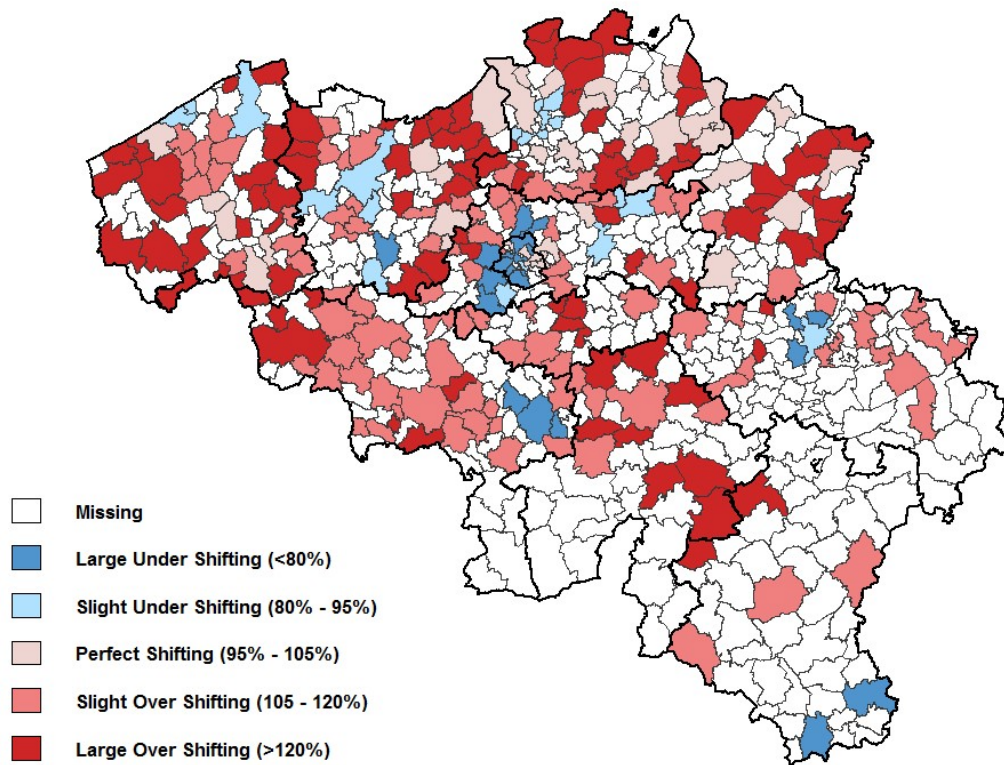


2.A Spatial Maps of Tax Pass-Through

Product A

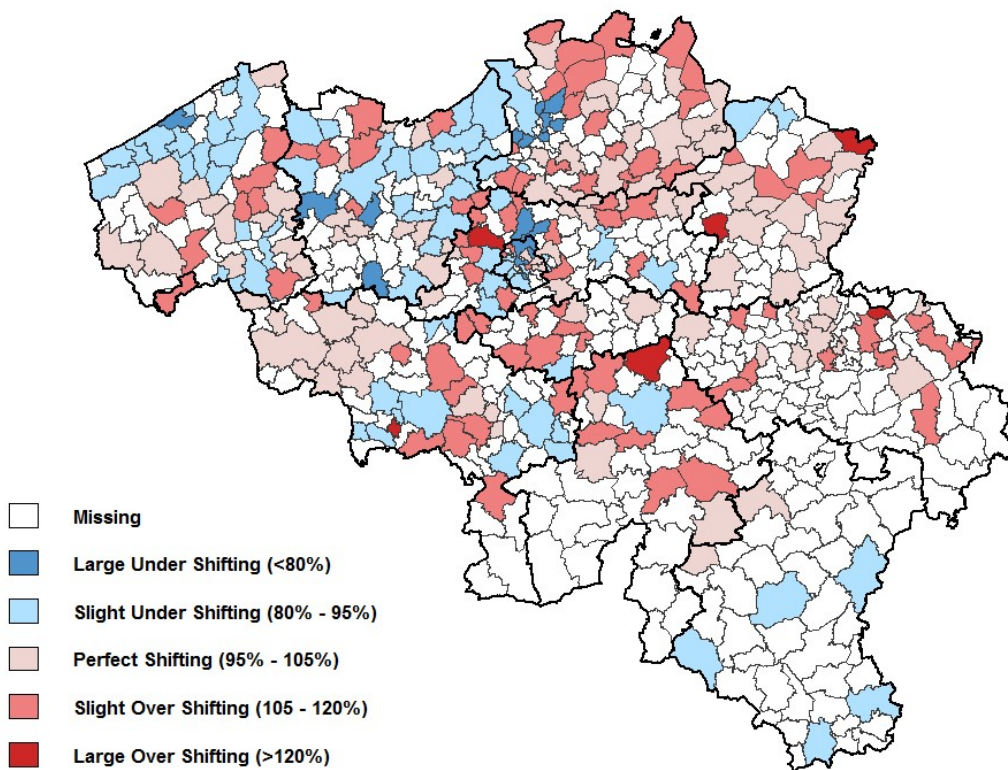
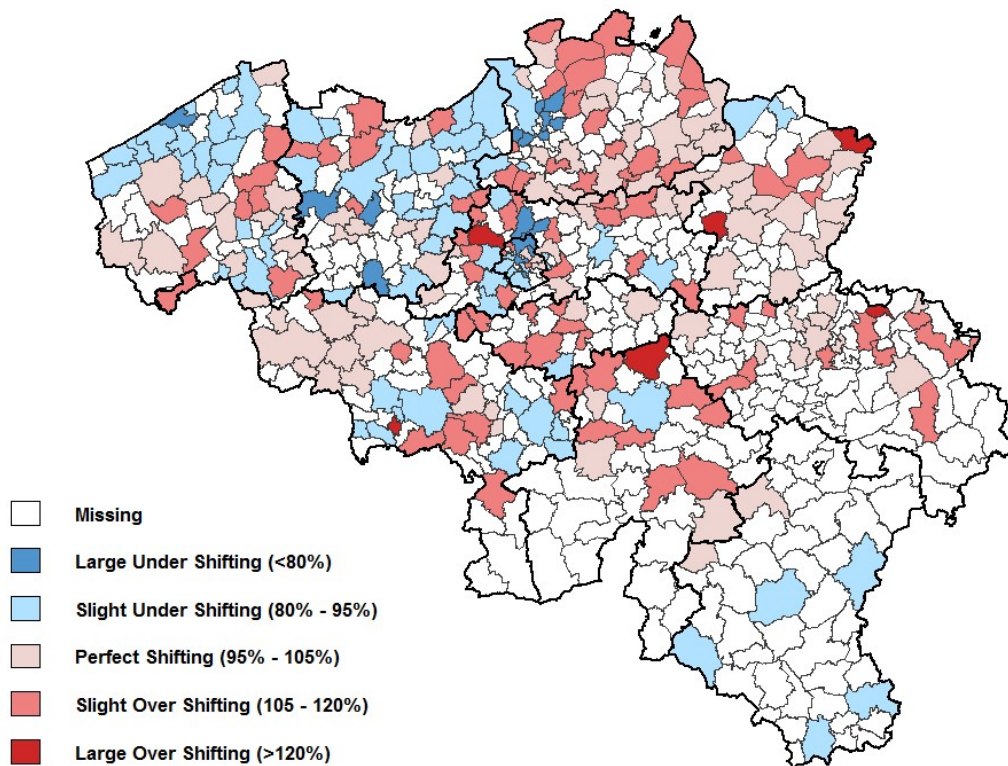


Product B



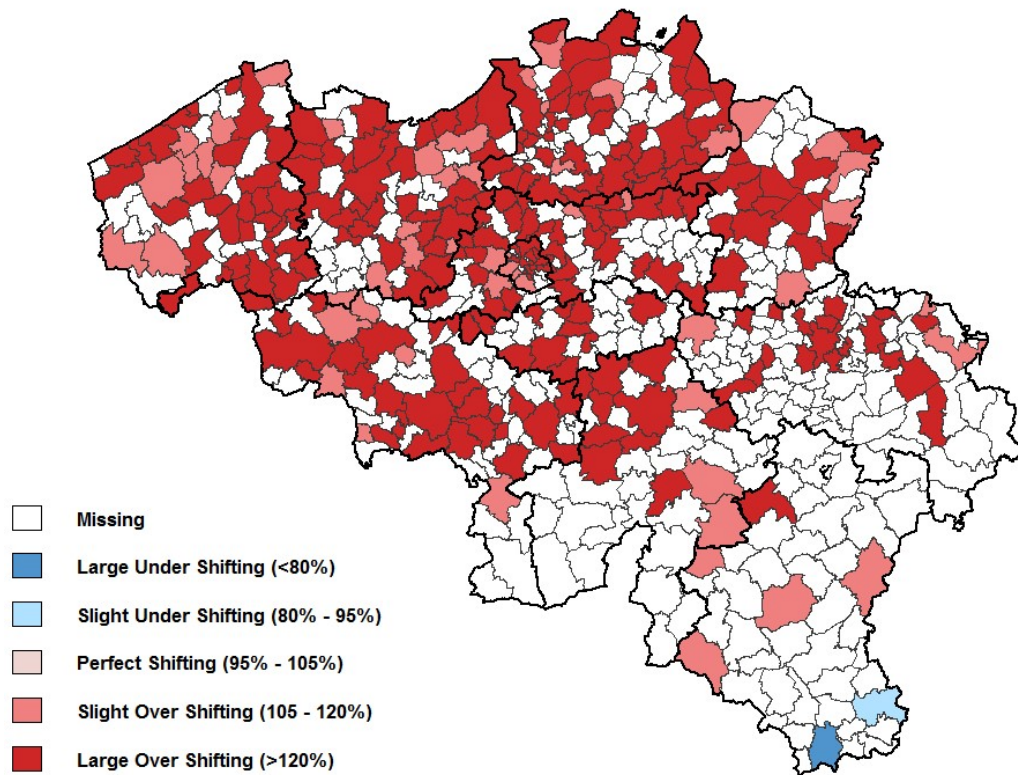
Product C

Product D



Product E

Product F



3.A Robustness Check on Competition Effect

The model estimated to account for the heterogeneity in the evolution of spirit prices across control stores during the post reform period is specified as follows:

$$\begin{aligned} P_{jit} = & \beta_0 + \delta_i + \beta_2(post_{reform}) + \beta_3(post_{reform} \times \log(GDP)_i) + \\ & + \beta_4(post_{reform} \times \log(Pop_density)_i) + \alpha_1(treated_i \times post_reform) + \\ & + \alpha_2(treated_i \times post_reform \times \log(GDP)_i) + \\ & + \alpha_3(treated_i \times post_reform \times \log(Pop_density)_i) + \\ & + \sum_P \alpha_P(\gamma_{P_i} \times treated_i \times post_reform) + \chi_i + \varepsilon_{it}. \end{aligned}$$

Where the two interaction terms $(post_{reform} \times \log(GDP)_i)$ and $(post_{reform} \times \log(Pop_density)_i)$ control respectively for the difference in the after tax price across French stores with different levels of GDP and population density. While coefficients α_2 and α_3 measure respectively the heterogeneity in treatment effect across different level of GDP and population density. As for model 3, the interaction terms between treatment variable and provincial dummies are included in order to account for differences in consumer preferences over geographical areas.

Table 11

Population Density as a proxy for Competitive Pressure						
	Product					
Coefficients	A	B	C	D	E	F
GDP×P (β_3)	-0,034 (0,116)	-0,129 (0,272)	-1,069 (1,170)	-0,906 (0,687)	-1,119*** (0,348)	-1,150** (0,445)
Density×P (β_4)	-0,037 (0,11)	0,048 (0,057)	0,290 (0,260)	0,164 (0,143)	-0,097 (0,060)	-0,182* (0,092)
GDP×T (α_2)	0,502 (0,536)	0,311 (0,313)	-0,852 (1,160)	1,25*** (0,702)	1,803*** (0,444)	1,210*** (0,055)
Density×T (α_3)	-0,132 (0,118)	-0,383*** (0,088)	-0,407 (0,260)	-0,358** (0,152)	-0,324** (0,112)	-0,193* (0,096)

Notes: For parsimony, just the coefficients of interest are displayed. The first two lines show the regression coefficients measuring how price evolved in the post reform period for control stores according to GDP and population density respectively. The last two lines instead show the heterogeneity in treatment effect according to both GDP and population density.

Table 11bis

Evolution of Spatial Price Dispersion							
Product		Average Price		Standard Deviation of Price		Levene's Test (homogeneity of σ^2)	
		Pre-reform	Post-reform	Pre-reform	Post-reform	F Value	Pr > F
Belgium	A	15,53	18,44	0,0761	0,2510	208,50	< 0,0001
	B	11,02	13,44	0,1479	0,5154	317,14	< 0,0001
	C	10,50	13,18	0,4780	0,6392	4,44	0,0354
	D	13,27	15,62	0,3647	0,6794	84,38	< 0,0001
	E	15,62	17,68	0,2739	0,6909	509,56	< 0,0001
	F	14,98	17,76	0,1465	0,1848	1,32	0,2503
France	A	16,19	16,06	0,5136	0,4245	4,85	0,0294
	B	11,68	11,62	0,2363	0,3112	0,33	0,5639
	C	12,76	12,56	0,4227	0,4373	0,06	0,8073
	D	14,27	14,31	0,5079	0,4305	0,43	0,5134
	E	14,94	14,87	0,5461	0,5598	0,03	0,8639
	F	14,68	14,57	0,5485	0,4754	2,72	0,1016

Notes: The sample is divided in two groups: Belgium (treated) and France (control). The second column shows the average product price for both groups before and after the tax hike. The third column displays the standard deviation of store prices from the average price before and after the tax hike. The last column shows the results of the Levene's Test on the homogeneity of price variance between the pre and post reform period. The null hypothesis of equal variances between the two periods ($H_0: \sigma_{PRE}^2 = \sigma_{POST}^2$) is rejected for all products in the treated group (except for F), while it is accepted for all products in the control group (except for A).