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VAT pass-through: the case of a large and permanent reduction in the market for menstrual hygiene products

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Abstract
This paper examines the price effects of a VAT (value-added tax) reduction for menstrual hygiene products in Germany. Several aspects make this VAT reduction particularly interesting: the reduction is exogenous to economic conditions, the reduction was substantial and permanent, and demand can be assumed to be inelastic. We find that the VAT reduction was completely passed through to consumers. In fact, pass-through rates of significantly more than 100% can be observed. We find that the excess pass-through occurred in relatively competitive market segments, and that it is almost fully explained by retailers rounding down prices after the reduction.

Keywords VAT · Pass-through · Hygiene products · Retail competition · Gender equality · Rounding effects · Tampon tax

JEL Classification H22 · H25 · H32 · K34 · L81

1 Introduction

Governments often use value-added tax (VAT) rate cuts to stimulate demand (post-2008 crisis[1]), improve consumer spending power (COVID-19 pandemic[2]) or to benefit specific groups (e.g., low-income households). More recently, governments have

[1] The UK implemented a temporary VAT cut in 2008 and 2009 (see, e.g., Blundell, 2009; Crossley et al., 2009).

[2] For example, Germany and Spain temporarily reduced VAT rates (see, e.g., Fuest et al., 2021, and the references therein.).

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reduced VAT rates on sanitary products in an effort to make the tax system more equitable from a gender perspective. In Germany, following a widely publicized petition to the German parliament, the VAT on feminine hygiene products, tampons and sanitary pads, was reduced from the standard rate to the reduced rate in 2020. Several countries, as well as individual states in the USA, have adopted similar tax policies favoring menstrual hygiene products in recent years.[3]

Whether or not policymakers achieve their stated goal depends on the extent to which the tax reduction translates into a price reduction. The question of how much of a VAT reduction is passed on to consumers is a source of debate around these VAT rate changes.[4] Previous evidence on this question suggests ambiguous results. For example, Montag et al. (2023) analyze the effect of a general temporary VAT cut on gasoline prices in 2020, finding less than full pass-through, and Dovern et al. (2023) analyze another temporary fuel tax cut in 2022, finding close to full pass-through, both in Germany.

This paper analyzes the pass-through of a permanent VAT reduction on menstrual hygiene products in Germany. We examine how the gross prices of different product types and in different store types and competitive settings changed within a time period that includes both the official decision to reduce the VAT and the date on which it took effect (the actual event). We find that retailers not only passed through the full VAT reduction but actually reduced prices by more than the VAT change would suggest.

Several aspects make this VAT reduction particularly interesting. First, the change can be considered exogenous in the sense that it was not triggered by market conditions. There were no changes in supply or demand that led policymakers to adopt the policy. The VAT reduction can be seen as a natural experiment caused by an exogenous shock. Second, the VAT cut was substantial and was made permanent. The tax rate was reduced from 19 to 7%. The reduction of 12 percentage points is relatively large compared to other VAT changes which often amounted to very few percentage points. Further, unlike other VAT policies observed in recent years, this rate reduction was made permanent. This is in contrast to many other VAT reductions that have been temporary. Third, the demand for these products can be assumed to be fairly inelastic within the common price ranges, and any price reduction due to the VAT cut is unlikely to increase demand. There is generally no acceptable way to substitute these products.[5] Short-term demand effects are also unlikely: Since the tax

[3] For example, Kenya, Canada, India, Malaysia, and Australia have no VAT on menstrual products, as do the US states of Nevada, New York, Florida, Connecticut, and Illinois (see, e.g., Zraick, 2019 for The New York Times; Masterson, 2022 for World Economic Forum). In addition, several European countries, such as Belgium, Cyprus, France, the Netherlands, Spain, and the UK, have changed the VAT rate applied to menstrual hygiene products to a reduced VAT rate (see online the Taxes in Europe Database (TEDB)). Since 2006, it has been legally permissible for EU Member States to apply only a reduced VAT rate to menstrual hygiene products (see EU Council Directive 2006/112/EC of 28 November 2006 on the common system of value added tax, OJ L 347, 11 December 2006).

[4] Uncertainty about the tax incidence was, for example, a stated reason why a petition launched in 2015 to abolish VAT on menstrual hygiene products in Germany was not considered further by the Petitions Committee of the German parliament (see Petition 58474).

[5] See also Cotropia and Rozema (2018) on both the elasticity and substitutability issues.

has been reduced, ex ante stockpiling does not make any sense, and postponement of demand is also unlikely for biological reasons. All in all, demand effects should be less of a concern in this setting. These characteristics make this VAT reduction an interesting case study.

The pass-through of this reform is examined using weekly price data at the retailer–product level. We exploit sharp price changes around the time of the reform. The data also allow us to examine robustness, for example, by varying the number of retailers and the week in which the reform took effect.

Our results are as follows. We find full and even excess pass-through. We observe excess pass-through in relatively "competitive market segments": Prices were reduced more (i) for the quantitatively more significant product type (sanitary pads), (ii) in the retail segment specializing in sanitary products (drugstores, as opposed to supermarkets), and (iii) for products that were offered by two or more retailers. The excess pass-through is almost entirely explained by the fact that retailers round (down) prices to popular decimals (like 0, 5, and 9) after the VAT reduction, and that this rounding occurs in the aforementioned competitive segments of the market. We further document that media attention may indeed have contributed to this behavior.

2 Related literature and theoretical background

2.1 Literature

This paper mainly contributes to the empirical literature on the pass-through of VAT changes. There is a broad literature investigating the effects of VAT changes on consumer prices. However, these studies mostly focus on the VAT change as a fiscal instrument (e.g., Blundell (2009) and Crossley et al. (2009) on the UK temporary VAT cut in 2008 and 2009). Also, in recent studies the VAT decrease is analyzed foremost in terms of the intended stimulus, like the temporary VAT reduction during the pandemic in Germany in 2020 (see Montag et al., 2021; Fuest et al., 2021). Both studying fuel prices, Montag et al. (2021) find lower pass-through rates for the temporary general VAT cut compared to Dovern et al. (2023) who analyze a temporary special fuel tax cut.

There is evidence that prices respond differently to tax increases than to tax decreases. Doyle and Samphantharak (2008), Carbonnier (2008) and Benzarti et al. (2020) analyze differences in tax incidence within increases and decreases. While Doyle and Samphantharak (2008) find symmetric price responses for short-term interventions, Carbonnier (2008) and Benzarti et al. (2020) identify asymmetries comparing the effects of VAT increases in contrast to VAT reductions. According to Benzarti et al. (2020) prices respond less to a VAT decrease than to a VAT increase. However, Hindriks and Serse (2022) find full pass-through for both a tax decrease and a tax increase without any asymmetries when analyzing VAT reforms of residential electricity prices in Belgium.

The effects of permanent VAT changes have mostly been studied when all consumer products are concerned (see Benedek et al., 2020; D'Acunto et al., 2022), but

specific markets and products have also been analyzed. For example, the effects of a permanent VAT decrease for services like hairdressing or housing repairs have been analyzed as have expensive products like cars (see Carbonnier, 2007; Kosonen, 2015).[6] Compared to these products and markets, menstrual hygiene products are in a very different price range and, as already mentioned, have a very inelastic demand.

Additionally, this paper contributes to the small literature on menstrual hygiene products and taxation. Cotropia and Rozema (2018) have also studied the effects of eliminating sales taxes on menstrual hygiene products. In their paper, they focus on demand-side differences and the distributional effects of such a tax policy and use data on purchases of menstrual hygiene products in New Jersey and surrounding states from 2004 to 2006 to study the incidence of the tax using a difference-in-differences approach. Cotropia and Rozema (2018) find that the tax cut is fully shifted to consumers, but not equally distributed across different consumer groups. While the tax cut reduced prices for low-income consumers by more than the size of the tax cut, the tax repeal reduced prices for high-income consumers by less than the size of the repealed tax. As the authors state, their pass-through estimates are partly driven by changes in the use of coupons. Cotropia and Rozema (2018) also attempt to find supply-side differences to explain the pass-through variation for different consumer groups. For pass-through differences by income, they find no significant differences across products in a store but within a product in different stores.

In contrast to Cotropia and Rozema (2018), our paper analyzes supply-side effects and differences. In addition to analyzing different competitive segments, we focus on explaining the observed excess price reduction and provide valuable insights into firm pricing.

Furthermore, Rüll (2020) explores different strategies to reduce the tax burden on menstrual hygiene products. The paper focuses on the possibility of promoting sustainable products and discouraging companies along the supply chain from increasing their profit margin when the tax burden is reduced. For a more recent review of different tax policies and their impact on the affordability of menstrual hygiene products, focusing on low- and middle-income countries, see Rossouw and Ross (2020).

Our paper also provides some insights into the relationship between consumer attention and retail pricing. As has been shown in several papers (see, e.g., Dickson & Sawyer, 1990; Evanschitzky et al., 2004; Vanhuele & Drèze, 2002; Vanhuele et al., 2006; Loy et al., 2020), consumers' knowledge and memory of retailer prices are highly imperfect. It appears that price knowledge is more or less limited to a relatively small range of products that are consumed regularly. As a consequence, retailers tend to compete most vigorously on those product prices that are actually remembered by many consumers. As we argue in our paper, increased attention to certain product prices may also intensify price competition for those particular products. Put differently, if the share of informed consumers increases while the share of uninformed consumers decreases as a result of increased media coverage

[6] Ardalan and Kessing (2021) also study the tax pass-through rates for different excise tax and VAT changes in European countries using beer prices.

of a particular product range, then price competition in that particular product range should also increase. This is consistent with recent findings by Montag et al. (2023) that informed consumers benefit significantly more from tax cuts (due to higher pass-through rates) than uninformed consumers.

Our findings can also be related to the literature on rounding and retail pricing, as we observe and discuss pricing preferences of retailers. Providing valuable insights from a behavioral perspective, in a recent study Strulov-Shlain (2022) analyzes firms' pricing behavior, especially 99-ending prices due to the assumed left-sided bias of consumers in a large retail scanner data sample. He finds evidence that firms' pricing behavior is more consistent with rule-of-thumb and heuristics than with optimization, given the demand structure. In another recent study on 99-ending prices, Conlon and Rao (2020) document a rigidity in retail prices caused by retailers' preference for prices ending in 99 and therefore changing prices in whole dollar increments.

Finally, this paper provides empirical insights related to the discussion on the effects of competition on pass-through rates. In addition to demand and supply elasticities, competitive pressure in a market is also related to VAT pass-through rates. Weyl and Fabinger (2013) show that pass-through under monopoly can be higher or lower than pass-through under perfect competition, depending on the curvature of demand. However, Fuest et al. (2021) find empirical evidence that in product markets with only a few suppliers, the price reduction induced by a temporary VAT rate cut was less pronounced than in product markets with many suppliers. In the following subsection, we discuss the theoretical background of our empirical analysis.

2.2 Theoretical background

Pertinent to our research is foremost the theoretical literature on tax pass-through. Which pass-through rate should we expect? Under perfect competition, the classical result is that the pass-through rate is affected by the ratio of the elasticities of supply and demand. The higher the ratio of the elasticity of supply to the elasticity of demand, the higher the pass-through rate and the higher the tax burden that falls on the inelastic side of the market (see Weyl & Fabinger 2013).[7] However, also for imperfectly competitive markets, the pass-through rate should be complete when demand is inelastic. While excess pass-through can occur with imperfectly competitive suppliers, it requires further curvature restrictions on demand. As pointed out by Conlon and Rao (2020), excess pass-through may be based on "unrealistic restrictions on demand curves". Also, Anderson et al. (2001) show that the pass-through rate for differentiated product markets with imperfect price competition is 100% if demand is inelastic.[8] As argued above and following Cotropia and Rozema (2018),

[7] Pass-through under third degree price discrimination is further analyzed by Miklos-Thal and Shaffer (2021).

[8] See also Genakos and Pagliero (2022).

we consider the demand for menstrual hygiene products inelastic within common price ranges. Hence, we conclude that the pass-through rate should be 100%.[9]

3 Chronology, data, and empirical strategy

3.1 Chronology

Our data set covers the time period with all stages relevant to the VAT reduction. Starting with week number (WN) 42 of 2019 (10/14/2019), the data set includes the week when the draft law was released (WN 43, 2019). Also, the week when the final vote in the German parliament, the Bundestag, took place (Thursday of WN 45, 2019) and the week when the second chamber, the Bundesrat, approved the new tax law (Friday of WN 48, 2019) are included. On January 1, 2020 (WN 1, 2020), the legislative amendment officially came into force and the applied VAT rate was 7% instead of 19% as before. A more detailed chronology can be found in Appendix A.

3.2 Data

The data set contains the gross prices which are also the posted prices for all female hygiene brand products offered by 10 large German retailers,[10] including leading drugstores, discounters, and supermarkets. The retailers included in our data set serve about 60% of the demand for hygiene products and 40% of the demand for grocery retailing in the German market. The data contain gross prices on a weekly basis for 21 weeks, namely from WN 42 in 2019 and WN 10 in 2020 (inclusive) at the national level.

Feminine hygiene products fall into two main categories: tampons and sanitary pads. Differentiated by the official Global Trade Item Number (GTIN), there are 309 unique products, 114 tampons and 195 sanitary pads. Using the product names, these can be categorized within the product type in terms of the size of the tampons and sanitary pads, as well as the number of items per package and other qualitative product characteristics. More details and descriptive statistics on our data can be found in Appendix B.

3.3 Empirical strategy

We conduct an event study defining a dummy variable named *after* taking the value 1 for periods after the treatment. We distinguish in our analysis the prices before WN 49 (excluding week 49) in 2019 as the "before" treatment period, and we

[9] In retail markets, tax pass-through rates can also depend on the nature of vertical contracts between retailers and manufacturers (see Haucap et al., 2021). However, this concern does not affect changes in the VAT rate, which are directly applied at the retail level and do not affect manufacturers net prices.

[10] The data were provided by a market participant and therefore anonymized. We thus may not provide further information on their identity, alternative distribution channels, or more narrow characteristics.

classify the prices after WN 1 (including week 1) in 2020 as the "after" treatment period.[11] The turn of the year was Tuesday to Wednesday, so most of week 1 was in 2020. Additionally, we define a dummy variable taking the value 1 for WN 49 to WN 52 in 2019, which are the weeks between the passing of the law and its entering into effect. This variable is named *between* and captures the anticipatory price effect of the VAT change.[12] Altogether, there are seven weekly observations before the identified transition period and four observations transition period, and there are nine weekly observations after the VAT change.

We work with the before-and-after distinction to determine the relative price change triggered by the official decision to reduce VAT and its introduction. Our approach can be formalized as follows:

$$price_{i,t} = \beta_0 + \beta_t \cdot between_t + \beta_t \cdot after_t + a_i + u_{i,t} \quad (1)$$

with $price_{i,t}$ representing the logarithmic prices of different identified retailer–product combinations i fluctuating over time t. The variable $between_t$ indicates the anticipatory effect of the passing of the law and $after_t$ the VAT reduction as a before-and-after dummy. We control for retailer–product fixed effects a_i.[13] The two dummy variables are interacted with others in the further analysis.

4 Results

We begin with a general overview of the effect of the VAT change and contrast it to the general CPI. We then provide a detailed analysis of the differential effects of product type, store type, and competition (given by the number of retailers offering the products). Further analyses can be found in Appendix C.3, C.4, and C.5. Unless otherwise stated, we perform panel regressions that include retailer–product fixed effects and report bootstrapped standard errors in our analysis. Furthermore, all tests reported are post-regression Wald tests with the corresponding p-value unless otherwise indicated.

4.1 Main results

Figure 1 shows the prices of the menstrual hygiene products over time, indicated changes are relative to $t = -11$. It shows the important interweekly transitions. The gross price effect as well as the anticipatory effect of the VAT reduction are evident. The figure shows the immediate reaction of the retailers to the approval of the law from $t = -5$ to $t = -4$.[14] Even before the official date of the VAT reduction, prices

[11] As a robustness check, we present the baseline and product-type result when week 1 belongs to the *between* period in Appendix C.1.2.

[12] Appendix C.1.3 presents a robustness check when week 48 belongs to the *between* period.

[13] Table 13 in C.1.5 compares our baseline regression for different fixed effects.

[14] See also Klug in Lebensmittelzeitung, an industry portal for the grocery retail and consumer goods industry focusing on Germany, of Dec 10, 2019.

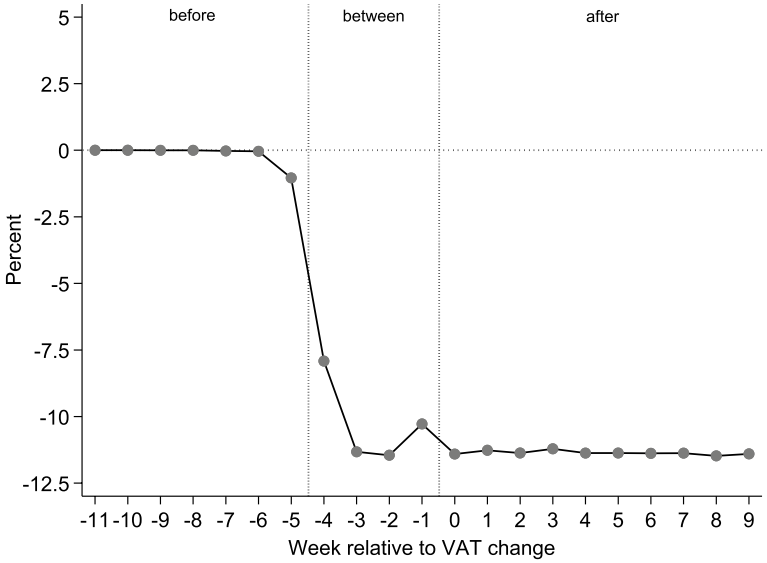

Fig. 1 This graph shows the price changes of menstrual hygiene products over time. Price changes are relative to $t = -11$. $t = 0$ represents the first week of 2020 when the law came into effect. $t = -5$ marks week number 48 in 2019 when the law was passed

started to drop. As expected,[15] the policy change was finalized on the Friday of WN 48 which equals $t = -5$ in Fig. 1. The VAT reduction was effective by $t = 0$.

This analysis is based on the time series of prices for treated products, with no untreated product group as a control group. The implicit counterfactual is the pre-reform price of the treated product group. Using this counterfactual seems reasonable because prices were very stable in the pre-reform period (i.e., the period before the law was passed).

A price reduction of 10.084% corresponds to a 100% pass-through. Since the prices in the data set include VAT, the tax reduction for menstrual hygiene products from 19 to 7% corresponds to a gross price reduction of 10.084% for each product affected by the VAT cut.[16] Thus, the benchmark for the full pass-through is 10.084%.

When we adopt a log-level approach, we can interpret the estimated coefficients (β_j) for dummy variables only as an approximation of the true marginal effect. The formula $(e^{\beta_t} - 1) \cdot 100$ gives the exact percentage change. Therefore, an estimated coefficient of −0.1063 corresponds to our benchmark of a gross price reduction of 10.084%. Estimated coefficients smaller than −0.1063 show an excess pass-through, while estimated coefficients larger than −0.1063 reflect a less than full pass-through.

Table 1 shows the baseline regression as described in the Empirical Strategy Sect. 3.3. Both the anticipation effect captured by the variable *between* and the tax

[15] The agenda for the meetings of the Bundesrat is announced 10 days in advance.

[16] The gross price P is $P_j = (1 + s_j) \cdot p$, $j = 0, 1$, with p reflecting the net price of the product and s_j being the VAT rate. Before the VAT reduction the tax rate is $s_0 = 0.19$ and after the law came into effect the new tax rate $s_1 = 0.07$ applies. The new gross price equals 89.916% since $P_1/P_0 = 0.89916$. The former gross price has been reduced by 10.084%.

Table 1 Baseline regression

	All products ln(price)
Between	−0.114*** (0.000573)
After	−0.119*** (0.000318)
Constant	1.031*** (0.00274)
H_0 : *after* = −0.1063	$p < 0.001$
Retailer–Product FE	✓
R^2	.9978904
Observations	17015

Bootstrapped standard errors are reported in parentheses. *between* captures the price reduction due to the anticipatory effect; *after* shows the price reduction after the VAT change. The H_0 row shows the Wald test for full pass-through. The null hypothesis is that the effect is equal to the benchmark for full pass-through. The benchmark is −0.1063. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

incidence captured by the variable *after* are highly significant for the full sample. Both are highly significant above the benchmark of full pass-through. The estimated price reduction after the VAT change is 11.23%[17] which indicates a 1.15 percentage-point excess reduction which can be translated to a 11.4% excess pass-through.[18] The price reduction increased significantly *after* the VAT change compared to the transition period *between*.

Remarkably, prices are already reduced in the *between* phase by more than the expected VAT change suggests. The estimated price reduction is 10.77% and reflects an excess price reduction of 0.69 percentage points.

The observed price drop is not the result of a general price shock, as Fig. 2 shows. While similar products with respect to primarily used inputs remain at the same price level as before or even show upward tendencies, the line with a square indicator in Fig. 2 shows a clear drop between November 2019 and January 2020.[19] We conclude that the price decrease is almost certainly the result of the VAT reduction for this product group.

Table 2 shows the results of a difference-in-differences estimation of the CPI data to size the effect. The treatment effect is significant ($p < 0.01$), and the estimated

[17] Note that $(e^{-0.119} - 1) \cdot 100 = -11.23$.

[18] This is calculated as follows: $1.15/10.084 = 0.114$

[19] The selected categories are: tampons, facial tissues, and other sanitary products which include menstrual hygiene products, and then toilet tissues and paper handkerchiefs. The products of these categories are mainly cellulose-based. Therefore, we can exclude an overlaying price trend caused by input factor prices for the tampon, facial tissues, and other sanitary products category. Further, a large share of the products in these categories can be assumed to be necessities. Besides the similarity in input factors, demand for these products is rather stable.

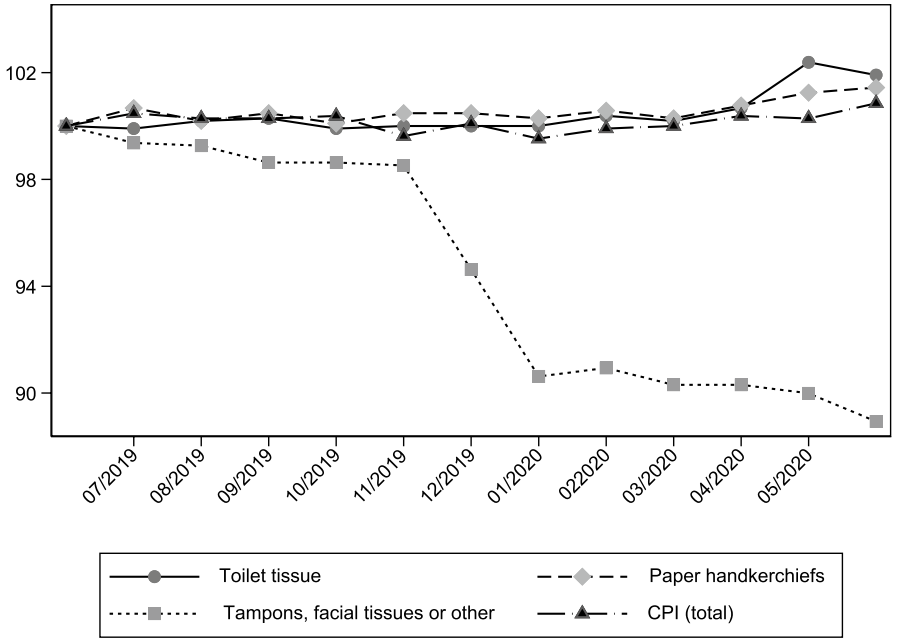

Fig. 2 This figure shows the Consumer Price Index (CPI) for assorted consumer goods for personal care. The triangle line shows the overall CPI. The line with square indicator represents the index including menstrual hygiene products. The dot and diamond line represent categories that rely on similar input but were not affected by the VAT change. The law to change VAT was passed in late November 2019. The VAT change came into effect in January 2020. Base 06/2019; Data source: Statistisches Bundesamt (Destatis) (2022)

Table 2 Difference-in-differences estimation results

Variables	Value
Diff-in-diff	−9.548**
	(0.412)
Constant	100.2**
	(0.168)
Observations	36
R^2	0.979
Mean control t(0)	100.2
Mean treated t(0)	99.07
Diff t(0)	−1.115
Mean control t(1)	100.8
Mean treated t(1)	90.18
Diff t(1)	−10.66

Control group: Toilet tissue and paper handkerchiefs. Treated: Tampon, facial tissues, or other. $t(0)$: 06/2019 - 11/2019; $t(1)$: 01/2020 - 06/2020. 12/2019 is excluded (anticipatory effect after passing of the law in November 2019). Means and standard errors are estimated by linear regression. Standard errors are reported in parentheses. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

size of the reduction is not significantly different from the size of the VAT reduction ($p = 0.202$).

4.2 Heterogeneity

This section analyzes the heterogeneous price effects within the data. We distinguish between the two product types, between the two different store types, and between the degree of competition (one retailer vs. more than one retailer offering the product). Table 3 presents the regression results and post-regression tests evaluating the estimates against the full pass-through benchmark.

Table 3 Heterogeneities

	Product type ln(price)	Store type ln(price)	Competition ln(price)
Between	−0.124***	−0.108***	−0.101***
	(0.000648)	(0.000565)	(0.00195)
After	−0.127***	−0.111***	−0.106***
	(0.000470)	(0.000369)	(0.00102)
Between × tampon	0.0250***		
	(0.00115)		
After × tampon	0.0181***		
	(0.000542)		
Between × drugstore		−0.00967***	
		(0.00108)	
After × drugstore		−0.0143***	
		(0.000611)	
Between × competition			−0.0143***
			(0.00204)
After × competition			−0.0147***
			(0.00106)
Constant	1.031***	1.031***	1.031***
	(0.00274)	(0.00274)	(0.00274)
$H_0 : after = -0.1063$	$p < 0.001$	$p < 0.001$	$p = 0.49$
H_0:$after + after \times interaction = -0.1063$	$p < 0.001$	$p < 0.001$	$p < 0.001$
Retailer–Product FE	✓	✓	✓
R^2	.9980533	.9979643	.9979146
Observations	17015	17015	17015

Bootstrapped standard errors in parentheses. In the Product type column, *between* and *after* show the price reduction for sanitary pads; × *tampon* shows the difference for tampons. In the Store type column, *between* and *after* show the price reduction for other stores; × *drugstore* shows the difference for drugstores. In the Competition column, *between* and *after* show the price reduction without competition; × *competition* shows the difference with competition. The H_0 rows show the Wald tests for full pass-through. The null hypotheses are that the effect is equal to the benchmark for full pass-through. The benchmark is −0.1063. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

4.2.1 Product-type differences

With sanitary pads and tampons, we observe two different product types in our data. We have around 58% sanitary pads and 42% tampons. In Table 3 the first column shows the regression results for the two different product types. For sanitary pads we find a significantly larger price reduction than a full pass-through *after* the VAT change. For tampons the price reduction *between* the passing of the law and the coming into effect was more restrained and around one percentage point below 10.084%, but the estimated effect *after* the VAT change exceeded the full pass-through benchmark significantly. We find a significant difference between the two product types.

4.2.2 Store-type differences

Menstrual hygiene products belong to the drugstore category. Although also supermarkets offer products from this category, only drugstores offer a greater variety within the individual product groups. We observe that around 55% of the data are from drugstore-type outlets.

Table 3 the second column shows the regression results for drugstores compared to other stores in column Store type. The price reduction of other stores exceeds the full pass-through benchmark of 10.084% significantly *after* the VAT change. Drugstores reduce their prices by around one percentage point more in the *between* phase and by around 0.5 additional percentage points when compared to other stores *after* the VAT change. Both additional effects are significant.

4.2.3 Retailer competition

We measure competition with respect to the number of retailers offering a certain product. Products offered by just one retailer are referred to as without competition while products which we find in two or more retailers are called with competition. In our data, we classify around 2.5% as products without competition. Products without competition are presumably niche products, as fewer retailers are interested in selling them; they must not be confused with products sold by monopolies.

Table 3 the third column shows the regression results when we distinguish between products with and without competition. The estimated price reduction of a product without competition *after* the VAT change is not significantly different from the 10.084% benchmark. The price reduction related to competition is highly significant *after* the VAT change, and the reduction for products with competition significantly exceeds the benchmark of 10.084% by around 1.4 percentage points.

Since the data set does not cover the entire supply side, this number must be interpreted as a proxy for the true number of retailers. In fact, some of the products stocked by only one retailer in our sample might actually be offered by more than one retailer in the whole market. As a result, the estimate when only one retailer offers a product can be interpreted as an upper bound of the relative price effect. Since we observe a smaller price change for our one retailer estimate, the real

difference between one retailer and more than one retailer stocking a product may be larger than our results suggest.

5 Explanations for excess pass-through

5.1 Net price reduction

The excess pass-through identified in the results section implies a reduction in net prices, revealing the loss of retail margin. Figure 3 shows the changes in net prices over the observed period. In the interim period,[20] net prices were reduced by about 11 percentage points, which translates directly into a loss of retail margin. After the VAT change, net prices remain around one percentage point below the earlier price level.

In the following section, we discuss the main channel of the excess pass-through rate: rounding effects. In a subsequent section, we explain what drives this effect and how it interacts with the identified heterogeneities.

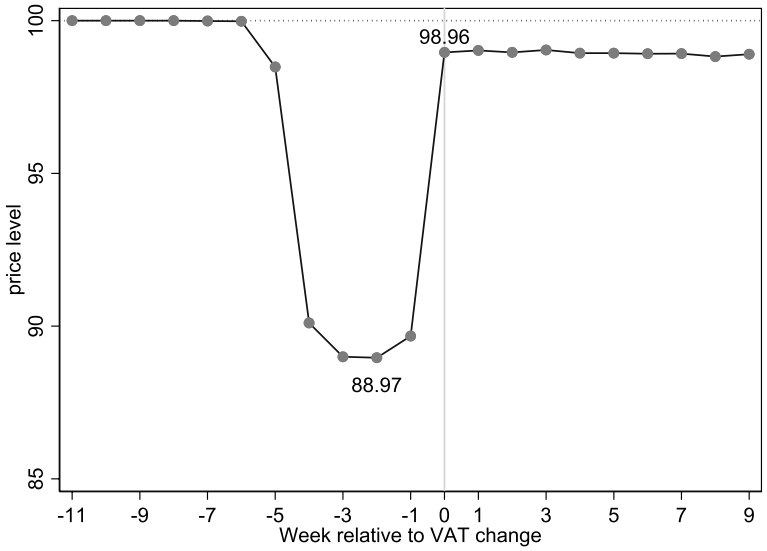

Fig. 3 This figure shows the normalized net price (without VAT) evolution over time. $t = -5$ marks week number 48 in 2019 when the law was passed. $t = 0$ represents the first week of 2020 when the law came into effect. The price level is normalized to $t = -11$

[20] We refer to this as the *between* phase in our regressions.

5.2 Rounding

A substantial literature indicates that retailers have a general preference for (gross) prices to end with a 0, 5 or 9 in the second decimal.[21] The retailers in our data are no exception: we observe these second decimals for more than 98% of all price observations both before and after the tax reduction. Six retailers set all prices ending with one preferred second decimal while four retailers use two or all three common decimals.

Preference for specific second decimals demands adjustments of net prices to match the targeted gross price when the VAT changes, and we observe almost exclusively downward-adjusted net prices, namely in 91.55% of retailer–product combinations.[22] Typically, retailers' net price adjustments have leeway in either direction: Compared to the benchmark when the new VAT is mechanically applied, they can round down or up. What they almost always do in our data is rounding down.

To further illustrate the rounding-down effect, Fig. 4 shows the distribution of differences between the expected and actual gross price after the VAT change for the observed retailer–product combinations.[23] The mean difference of these prices is 2.93 euro cents. The figure also shows a wide range of realized price differences. Values below zero indicate a less than full pass-through of the VAT change. The corresponding net prices have been adjusted upwards. Price differences between 0 and 10 euro cents can be explained by rounding to a specific second decimal place. Most of the values in the Fig. 4, 86.72%, fall within this range.

Crucially, retailers round not just to one of the usual second decimal places, but to the same decimal place as before the VAT change, which we call consistent rounding. Indeed, this is the case for 86.28% of the observations. We focus on this most common strategy in the following.

Given the rounding to the same second decimal regularity, the maximum difference between the actual and rounded gross price is 9.99 euro cents. As an example, assume a gross price of 4.99 euro including a VAT of 19%.[24] The corresponding net price is 4.99 euro/1.19 $\approx$ 4.1933 euro. With the new VAT rate of 7%, the new gross price would be 4.4868 euro. Now, if this gross price were rounded down to a 9 in the second decimal, the new gross price would be 4.39 euro, which means a gross price

[21] These preferences result from the so-called pricing in the nines phenomenon (see Basu, 1997) which uses the idea that consumers ignore the last digits of a price (see, e.g., Nagle & Holden, 1987) and has been observed for decades (see, e.g., Ginzberg, 1936, who reported this phenomenon as "customary pricing"). Effects of this pricing strategy have been studied, e.g., in Schindler and Kibarian (1996) Schindler and Kirby (1997), and Stiving and Winer (1997). Basu (1997) provides an economic explanation for this pricing strategy. Strulov-Shlain (2022) added just recently to this literature, providing empirical evidence against this strategy from a retailer's point of view, as lost profits by setting .99 instead of the closest integer price exceed the revenue from additional demand.

[22] We calculated expected prices after the VAT change based on the median price before the law was passed. Then we calculated the difference between this expected price and the actual price after the VAT change.

[23] The expected gross price results when the new VAT is applied without changing the net price.

[24] In our data, prices range from 0.75 euro to 6.45 euro, as shown in the descriptives table in the Appendix B.

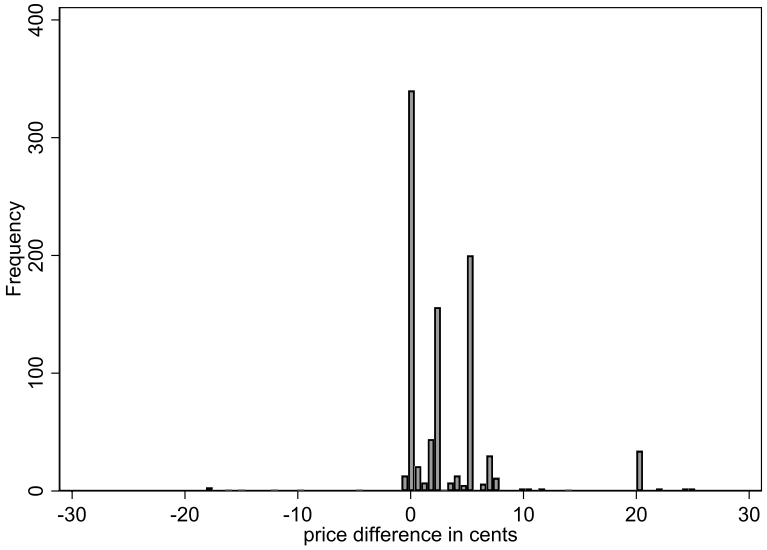

Fig. 4 This figure shows the differences between the expected price after the VAT change (based on the median price before the law was passed) and the actual median price after the VAT change in euro cents for retailer–product combinations. A negative sign indicates an upward effect which means the actual price was higher than the expected while a positive sign indicates excess pass-through. Two outliers were removed (−86.07 and −40.24) to improve readability

difference of 9.36 euro cents. Obviously, the corresponding net price also changes to 4.1028 euro, which is an absolute reduction of the net price by 9.05 euro cents. The gross price in this example has been reduced from 4.99 euro to 4.39 euro, a reduction of 60 euro cents. This is a relative reduction of 12.03%, which is 1.94 percentage points higher than the 10.084%. This difference in relative price reduction varies for different prices and may increase for smaller gross prices, as the maximum difference between the actual and rounded gross price remains at 9.99 euro cents.

We now estimate the effect of the "rounding to the preferred decimals" strategies and their magnitudes in our data. Table 4 shows the results, and the "rounding only" dummy equals one only if a retailer uses the strategy of rounding the price of a product to one of the most preferred decimals, namely 0, 5, and 9, before and after the VAT change without consistent rounding, while the "consistent rounding" dummy equals one if a retailer uses the same of the most preferred decimals before and after the VAT change.[25]

First, we find that for retailer–product combinations without these rounding strategies (no rounding), the price reduction of 9.95% *after* the VAT change is not significantly different from the benchmark ($p = 0.8053$). For these, we find full pass-through, but no excess pass-through. For prices that are rounded, but not consistently

[25] The proportions of these three groups are as follows: Consistent rounding: 86.28%, rounding only: 13.28%, no rounding: 0.44%.

Table 4 Rounding and consistent rounding effects

	Rounding ln(price)
Between	−0.117***
	(0.00516)
After	−0.105***
	(0.00627)
Between × rounding only	0.00776
	(0.00524)
After × rounding only	−0.00643
	(0.00631)
Between × consistent rounding	0.00275
	(0.00518)
After × consistent rounding	−0.0156*
	(0.00626)
Constant	1.031***
	(0.00274)
$H_0 : after = -0.1063$	$p = 0.8053$
$H_0 : after + after \times rounding\ only = -0.1063$	$p < 0.001$
$H_0 : after + after \times consistent\ rounding = -0.1063$	$p < 0.001$
Retailer–Product FE	✓
R^2	.9979059
Observations	17015

Bootstrapped standard errors in parentheses. This table shows the rounding effect when prices are rounded to 0, 5, or 9 in the second decimal (denoted by × *rounding only*) and the rounding effect when prices are consistently rounded to the same second decimal (denoted by × *consistent rounding*). There is no overlap between these two segmentations. *between* captures the price reduction due to the anticipation effect; *after* shows the price reduction after the VAT change. The H_0 rows show the Wald tests for full pass-through. The null hypotheses are that the effect is equal to the benchmark for full pass-through. The benchmark is −0.1063. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

(rounding only), we find no significant difference from prices that are not rounded ($p = 0.3083$). When prices are consistently rounded to the same decimal as before the VAT change (consistent rounding), they are significantly reduced by 1.55 percentage points more than those without rounding which adds up to a reduction of 11.49% and is a highly significant excess reduction. Thus, the rounding strategy significantly amplifies the price reduction.

We conclude that the observed excess pass-through is mainly driven by rounding. In particular, the strategy of rounding to the same second decimal (consistent rounding) contributed to excess price reduction.

5.3 Media coverage

The question remains as to why retailers largely round down, and why they do the opposite in some cases. We argue that media attention led to this behavior.[26] We provide both anecdotal evidence and quantitative data on this issue.

As for anecdotal evidence, there are press articles and retailers' promotional efforts. These promotion activities are mainly observed in the transition phase and were linked to the large net price reduction in this phase. News articles covering the VAT change were published not only in tabloids, but also different international, national, and regional newspapers.[27] The variety of outlets suggests a broad coverage, reaching different groups of consumers. Around the same time, retailers were actively promoting the VAT cut and the corresponding price reduction even before the tax change was legally implemented.[28] This is a substantial amount of attention for a product that under other circumstances would hardly even be noticed by the media.

To further quantify the media attention, we systematically searched for press articles and Twitter posts on the topic. The data sets result from own research using free online sources like Google News and scraping Twitter data. Figure 5 shows data on various (online) press articles covering the topic of VAT reduction for menstrual hygiene products as well as tweets posted on Twitter dealing with the topic.

There are two points in time when both press articles and tweets divert from their previous trend. The first point in time is connected to the announced intention of the Ministry of Finance to reduce the applied tax rate for menstrual hygiene products by January 1, 2020. Both tweets and also, somewhat later, press articles resulted in an increase of attention reflected by a higher number of tweets and articles. Thereafter, the number of tweets remained on a slightly increased trend with only one small level-shift when an ongoing progress in the legislative process could be observed. Also, press articles covered this period on a moderate level.

The second point in time is around two weeks after the VAT reduction came into effect. In WN 3 of 2020 an industry portal for grocery retail and consumer goods industry focusing on Germany reported on rumors of planned price increases by manufacturers.[29] These rumors lead to a media response of similar size as the

[26] Hindriks and Serse (2022) also argue that their analyzed tax cut was widely covered in the media and, therefore, firms were publicly pressured to pass through the entire VAT cut. Relatedly, the size differences of pass-through rates between Montag et al. (2023) and Dovern et al. (2023) are presumably attributable to the greater or more direct focus on fuel price tax cuts in the latter study.

[27] See, for example, online sources from: Augsburger Allgemeine (8 Nov 2019), Gala (8 Nov 2019), The New York Times (12 Nov 2019), The Washington Post (12 Nov 2019), tagesschau (29 Nov 2019), RTL (4 Dec 2019), Mitteldeutsche Zeitung (4 Dec 2019), Handelsblatt (12 Dec 2019), all retrieved on March 15, 2023.

[28] See, for example, press releases from dm (2 Dec 2019), Lidl (5 Dec 2019), EDEKA (9 Dec 2019), Netto (9 Dec 2019), all retrieved on 15 March 2023. Similarly, promotion activities were observed for other VAT cuts, see, e.g., Crossley et al. (2009) who provide anecdotal evidence on active retailer promotion on a temporary VAT cut in the UK.

[29] The factory selling price between manufacturer and retailer is usually negotiated in annual meetings (see, e.g., Kaas, 1993; Bundeskartellamt, 2014).

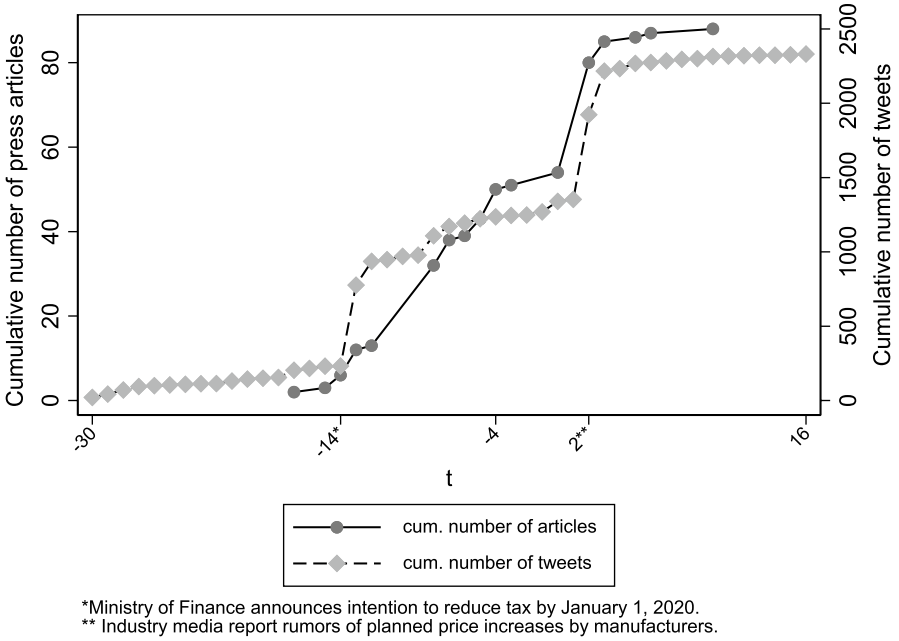

Fig. 5 This figure shows the evolution of media coverage on the VAT reduction for menstrual hygiene products. The diamonds represent the cumulative number of tweets including either the words "tampon-tax" and "Germany" combined or the German word "tamponsteuer" starting WN 23 in 2019 until WN 17 in 2020. The dots represent the number of (online) press articles covering the topic from summer 2019 until late spring 2020. These time horizons frame the period of our price observations generously

announcement of the Ministry of Finance did before. Both press articles and tweets increased again on this negative news from a consumer perspective. This supports the assumption about media coverage and attention and can be interpreted as an indication that retailers would also have been affected by negative publicity if they had not passed through the entire reduction.

The intense media coverage of this VAT reduction may have influenced consumer attention and thus shifted the price competition between retailers toward tampons and sanitary pads, as discussed above. If media coverage draws consumers' attention to these products, supermarkets and drugstores can be expected to compete more vigorously in these product lines to attract customers to their stores. On the other hand, lowering prices on products to which consumers pay little or no attention is not attractive to retailers, because retailers lose mark-ups on these products without attracting enough additional customers to their stores. Therefore, the best solution is to lower prices and forgo margins on products that consumers pay significant attention to. In addition, any media report of a retailer passing through less than 100% could have resulted in negative publicity, especially given the highly political campaign surrounding the tax cut, which suggested that the previous VAT rate

negatively discriminated against women. Therefore, retailers rounded down prices to avoid negative press coverage and implemented a larger price reduction than the VAT change would have implied.

To sum up, the attention in the form of press reports, tweets, and advertisements created pressure and expectations for the pass-through of the VAT cut, especially through the claim of negative discrimination used to support the campaign. While we cannot provide evidence of the counterfactual—that passing through less than 100% would have led to a loss of sales—we firmly conjecture that media coverage and attention did lead to the high share of rounding-downwards discussed in Sect. 5.2.

5.4 Excess pass-through in "competitive segments"

In the previous sections, we established that excess pass-through is primarily a result of the rounding-downward effects triggered by media coverage and attention. It remains for us to demonstrate how the use of the rounding strategy is related to the heterogeneities in pass-through rates shown in the results section.

Tables 5 and 6 show the details. Table 5 provides descriptive insights into these heterogeneities when we condition on whether retailers round to the most preferred second decimals or not. The regression results presented in Table 6 show the impact of store type, product type, and retailer competition when we control for rounding.

Column (1) of Table 6 includes the product-type heterogeneity, while Table 5 column (1) shows the number of observations for the two product types differentiated by rounding. We observe that close to all sanitary pad products and all tampon products round. The regression results show a highly significant higher price reduction for sanitary pads than for tampons when both round during the *after* phase of the VAT change.[30] This finding is consistent with the results from Sect. 4.2.1, which also show a larger reduction for sanitary pads. We conjecture that sanitary pads are the more "competitive" product as there are more variants.

The second column of Table 6 presents the store-type heterogeneity. Table 5 column (2) shows that all drugstore products are rounded. The regression results indicate that drugstores reduce their prices more than other grocery stores by a highly significant margin, given that both round *after* the VAT change.[31] This finding is consistent with Sect. 4.2.2 and is likely due to menstrual hygiene products being associated more with drugstores, which makes them a competitive core product for these retailers, but less so for regular supermarkets.

The competition heterogeneity is included in column (3) of Table 6. Table 5 column (3) shows the number of observations with and without competition differentiated by rounding. In the regression results, we see highly significantly more price reductions with competition both before and after the VAT change.[32]

[30] The estimated difference is about 1.8 percentage points after the VAT change.

[31] The estimated difference is around 1.4 percentage points after the VAT change.

[32] The estimated difference is about 1.4 percentage points after the VAT change.

Table 5 Rounding and heterogeneities

(1)			(2)			(3)		
Product type × Rounding			Store type × Rounding			Competition × Rounding		
	Freq.	Percent		Freq.	Percent		Freq.	Percent
Sanitary pads			No drugstore			No competition		
Rounding = 0	4	0.76	Rounding = 0	4	0.97	Rounding = 0	1	1.41
Rounding = 1	521	99.24	Rounding = 1	409	99.03	Rounding = 1	70	98.59
Total	525	100	Total	413	100	Total	71	100
Tampons			Drugstore			Competition		
Rounding = 0	0	0	Rounding = 0	0	0	Rounding = 0	3	0.36
Rounding = 1	386	100	Rounding = 1	498	100	Rounding = 1	837	99.64
Total	386	100	Total	498	54.67	Total	840	100
Total			Total			Total		
Sanitary pads	525	57.63	No drugstore	413	45.33	No competition	71	7.794
Tampons	386	42.37	Drugstore	498	54.67	Competition	840	92.21
Total	911	100	Total	911	100	Total	911	100

This table shows descriptive insights into the heterogeneities of retailer–product combinations in the 'Total' row and descriptive insights within the competitive segments conditioned on whether retailers round to the most common second decimals (*Rounding* = 1)

This result is consistent with the result in Sect. 4.2.3 and is also intuitively consistent. We divide the products into two groups: with and without competition. The term "without competition" should not be confused with a monopolistically supplied product. In our context, "without competition" means that we are talking about special niche products that are offered by only one retailer and therefore receive less media attention, while the products with competition are arguably more popular. Thus, it is not surprising that, once again, the pressure of media attention had a greater effect on the products with competition than on those without.

We conclude that the excess pass-through we observe in certain subsamples is fully consistent with the rounding effect. We still observe differences across competitive segments. In Appendix C.2 we repeat this analysis when we condition on consistent rounding and excess pass-through.

Table 6 Products rounding interacted with

	+ Product type ln(price)	+Store type ln(price)	+Competition ln(price)
Between	−0.117***	−0.117***	−0.110
	(0.00526)	(0.00526)	(0.0000)
After	−0.105***	−0.105***	−0.0832***
	(0.00575)	(0.00575)	(0.0106)
Between × rounding	−0.00709	0.00907	0.00962***
	(0.00526)	(0.00522)	(0.00177)
After × rounding	−0.0222***	−0.00613	−0.0227*
	(0.00574)	(0.00569)	(0.0106)
Between × tampon	0.0250***		
	(0.00123)		
After × tampon	0.0182***		
	(0.000605)		
Between × drugstore		−0.00977***	
		(0.00115)	
After × drugstore		−0.0143***	
		(0.000628)	
Between × competition			−0.0102
			(0.00719)
After × competition			−0.0287*
			(0.0127)
Between × rounding × competition			−0.00414
			(0.00738)
After × rounding × competition			0.0143
			(0.0128)
Constant	1.031***	1.031***	1.031***
	(0.00271)	(0.00273)	(0.00268)
$H_0 : after = -0.1063$	$p = 0.7882$	$p = 0.7882$	$p < 0.05$
$H_0 : after + after \times rounding = -0.1063$	$p < 0.001$	$p < 0.001$	$p = 0.6524$
$H_0 : after + after \times interaction = -0.1063$	$p < 0.001$	$p < 0.05$	$p = 0.4228$
Retailer–Product FE	✓	✓	✓
R^2	.9980563	.9979651	.9979165
Observations	17015	17015	17015

Bootstrapped standard errors in parentheses. This table shows the different heterogeneities interacted with a dummy identifying prices with rounding to the most common second decimals (denoted by × *rounding*). In column +Product type *between* and *after* show the price reduction for sanitary pads; × *tampon* presents the difference for tampons. In column +Store type *between* and *after* show the price reduction for other stores; × *drugstore* presents the difference for drugstores. In column +Competition *between* and *after* show the price reduction without competition; × *competition* presents the difference with competition. The H_0 rows show the Wald tests for full pass-through. The null hypotheses are that the effect is equal to the benchmark for full pass-through. The benchmark is −0.1063. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

6 Conclusion

In this paper we studied the price effects caused by a VAT (value-added tax) reduction for menstrual hygiene products in Germany. The policy change was initiated by a petition in the parliament and campaigns, highlighting that these products are subject to the regular (i.e., the highest) VAT rate, but are purchased only by menstruating women, thus suggesting a negative discrimination. Exploiting a rich set of retail prices, we analyze the price level before the parliament's decision and after the implementation of the VAT reduction (plus a between phase). As demand for these products should be rather inelastic within certain price ranges and retail markets fairly competitive, we expected a 100% pass-through.

Our analysis shows not only a complete pass-through of the VAT reduction, but even excess pass-through. In our baseline regression, we found a 1.15 percentage-point excess price reduction which corresponds to a 11.4% excess pass-through. We also find the anticipation effect to be already similar in magnitude, as retailers cut prices as soon as the law is passed rather than waiting until it goes into effect. In further regressions, decomposing for different "competitive segments" of the market, we found substantial differences between subsamples: A higher excess pass-through in sanitary pads compared to tampons, in drugstores compared to grocery stores, and for more popular products which are stocked at more than one different retailer. In any case, the reduction was at least fully passed through in all segments and even more in some.

We cannot fully claim causality in the sense that without the passage of the law, the price level would have remained the same as before the reform. However, we are not concerned about a lack of rigor here, because the price change is sharp, coincides with the (passage of the) reform, and the price level is relatively stable before and after. Moreover, there is no such price drop for similar products not affected by the reform.

As for the channel of the excess pass-through, we find that the major part of it can be explained by "rounding to preferred decimals" effects. We have identified that almost all prices end with a 0, 5 or 9. In addition, a large proportion of prices stick to the same second decimals after the VAT reduction, which we identified as the most common rounding strategy in our data. The aforementioned differences in competitive segments persist when we control for rounding to the common decimals.

We relate the downward direction of rounding to the preferred second decimals pricing to evidence of media coverage and increasing attention to the VAT reduction. Thus, our paper adds to the recent literature on firm pricing and rounding to specific (second) decimals.

Our findings support the argument that VAT policies intended to benefit the consumers can be successful. In policy debates about such measures, there are frequent criticisms that firms do not pass through tax cuts or negatively factor subsidies to consumers into their pricing. We find no evidence of this. Our findings also suggest that the media can play an important role in shifting consumer attention toward the campaign and the concerned products, thereby incentivizing firms to pass on the tax cuts.

Appendices

Appendix A Detailed chronology

The timeline in Table 7 highlights the important stages of the decision process toward the VAT reduction. Although the process that started with the online petition began well before the first draft, the relevant stages are within our observed time period. The data set used in our analysis starts with WN 42 (10/14/2019) and therefore includes the week when the draft law was released. Also, the moment of the final vote in the German Bundestag in WN 45 (11/07/2019), the date when the legal process was approved in the Bundesrat on 11/29/2019 (Friday of WN 48 in 2019), and WN 1 in 2020 (01/01/2020), the date when the legislative amendment officially came into force, are within the observed time frame.

Appendix B Supplementary descriptives

We received our data set from a market participant and have anonymized the included retailers. The 10 retailers can be categorized as either drugstores or mainly grocery stores (referred to as "other stores"). These retailers account for over 60% of the annual sales in the German food retail sector.[33]

Table 7 Timeline from the petition to the passed law

In 2018	• Start of the petition "Die Periode ist kein Luxus" ("The period is not a luxury") on the platform change.org. (Non-binding for the parliament)
9th February 2019	• Date of submission of a petition to reduce the VAT for menstrual products in the Bundestag.
8th March 2019	• The tax reduction topic is in the media and a politician from the conservative ruling party speaks positively about a tax reduction demand.
16th April 2019	• The guerilla marketing activity named "The Tampon Book" was launched and the campaign started attracting more and more politicians to its side.
27th May 2019	• The petition in the Bundestag reaches the quorum of at least 50,000 signatures.
3rd September 2019	• A federal state requests that the Bundesrat deal with the issue at the earliest possible date.
4th October 2019	• The Minister of Finance announces the intention to reduce the tax as of January 1, 2020.
22nd October 2019	• The draft law on the tax reduction of menstrual products is fixed.
7th November 2019	• The Bundestag approves the draft law.
29th November 2019	• The Bundesrat approves the change in the tax law as proposed by the Bundestag before.
1st January 2020	• Menstrual hygiene products are taxed 7% instead of 19% VAT.

[33] Our calculation using data from Lebelsmittel Praxis, 2020, which is based on the NielsenIQ/Tradedimensions Top 30.

Our data set includes brand products from two product groups—tampons and sanitary pads—that are classified by a Global Trade Item Number (GTIN). These products come in various sizes and pack sizes, offering a wide range of options. Among the 114 tampon products, 97 (85.1%) are from the leading manufacturer brand (LMB), while the remaining 17 are from six other brands. Similarly, out of the 195 sanitary pad products, 168 (86.2%) are from the leading manufacturer brand, with the remaining 27 from six other brands. The share of retailers offering only one brand, the LMB, in stock is 40% in our data.

Table 8 Descriptive statistics

	Mean	Median	Std. Dev.	Min	Max	Obs
Total	2.77	3.05	0.96	0.75	6.45	17,015
Sanitary pads	2.55	2.89	0.93	0.75	4.79	9,895
Tampons	3.08	3.55	0.90	1.19	6.45	7,120
Drugstore	2.65	2.89	0.92	0.75	6.45	9,727
Other stores	2.94	3.10	0.97	0.75	4.79	7,288
Competition	2.70	3.05	0.90	0.75	6.45	15,739
No competition	3.63	4.29	1.16	1.19	6.45	1,276

This table shows descriptive insights into our data, including the differentiation by competitive segments

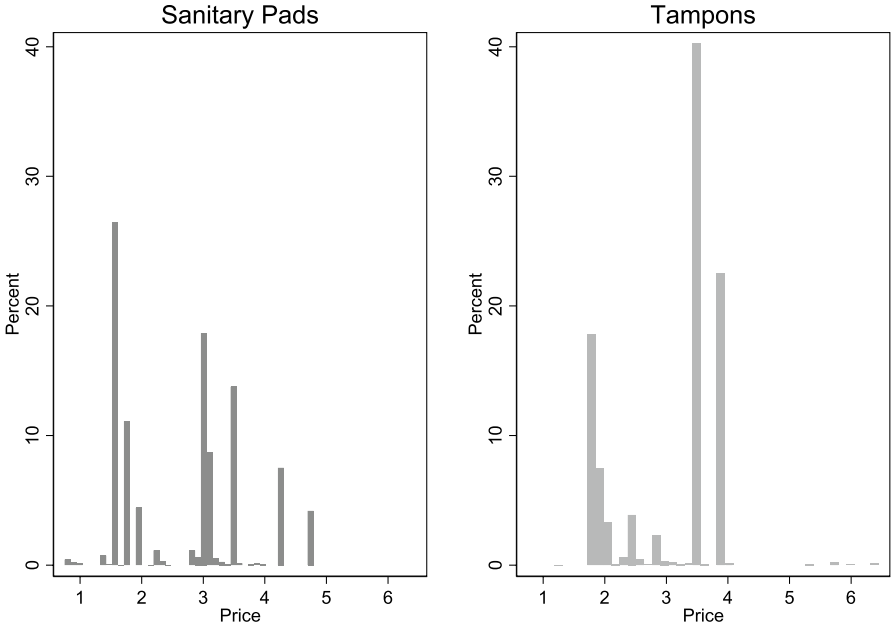

Fig. 6 This graph shows the distribution of prices for the two product types. The histogram on the left shows the percentage shares for sanitary pads. The histogram on the right shows the percentage shares for tampons

In Table 8, we provide descriptive statistics on the prices of these products based on the competitive segments that we identified. We differentiate between product types, store types, and products offered at one or more than one retailer (we refer to this as "without competition" and "with competition").

We observe that, on average, sanitary pads are priced 53 euro cents lower than tampons. Both product groups show significant price variation due to the pack size and other characteristics.

We also find that menstrual hygiene products are priced, on average, 29 euro cents lower in drugstores than in other grocery stores.

When we compare prices between products available at multiple retailers (popular products) and those available at only one retailer (more niche products), we find that the average price difference is 93 euro cents.

Figure 6 presents the number of distinct price observations for each product group. This illustrates that more than 60% of tampon products are priced between 3.50 euro and 4 euro and that prices above 4 euro represent a minor share. Compared to tampons, we see a more balanced distribution of sanitary pads around the median price of 2.89 euro.

B.1 Product types

We plot net prices over time by product type. Figure 7 shows net prices normalized to $t = -11$. The average net price change for tampon products between the passage

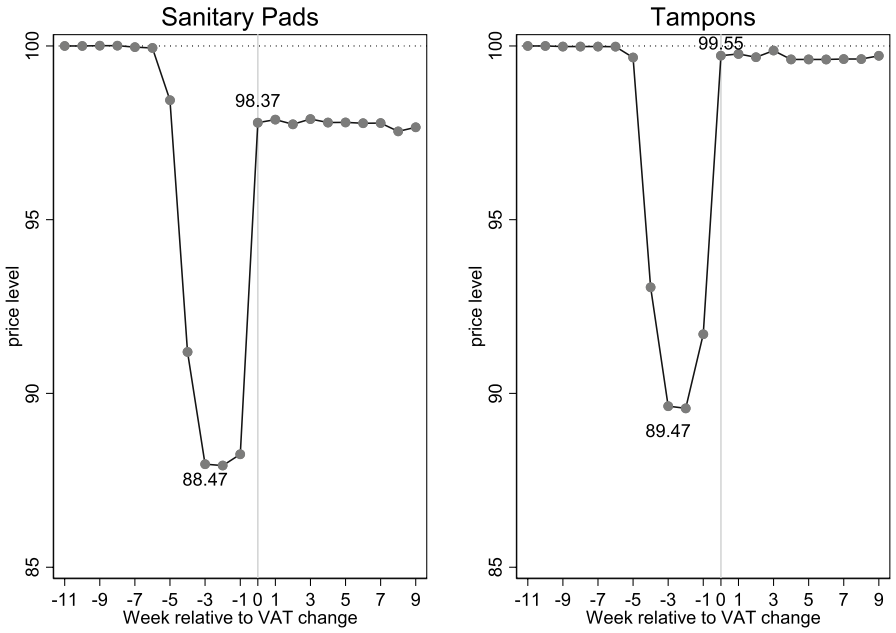

Fig. 7 This figures shows the normalized net price evolution over time separated by the product types. The graph on the left reflects the changes in net prices for sanitary pads while the graph on the right relates to tampons. $t = -5$ marks week number 48 in 2019 when the law was passed. $t = 0$ represents the first week of 2020 when the law came into effect. The price level is normalized to $t = -11$

of the law and the effective date of the VAT change was about 10.5 percentage points, and the excess price reduction after the VAT change is less than one percentage point.

The net prices of sanitary pads are reduced by one percentage point more than the prices of tampons. After the reform takes effect, sanitary pad net prices remain about one percentage point below tampon prices. The temporal net price reductions show the retailer's lost profits due to an actual net price reduction. Comparing the two types, the net price decrease in the *between* phase ($t = -5$ to $t = -1$) was more restrained for tampons. After the VAT change (from $t = 0$), the figure shows that net prices were stable for both product types.

B.2 Store types

We plot net prices over time by store type. Figure 8 shows net prices normalized to $t = -11$. The average net price change at drugstores between the passage of the law and the effective date of the VAT change was about 12 percentage points, and the excess price reduction after the VAT change is about two percentage points.

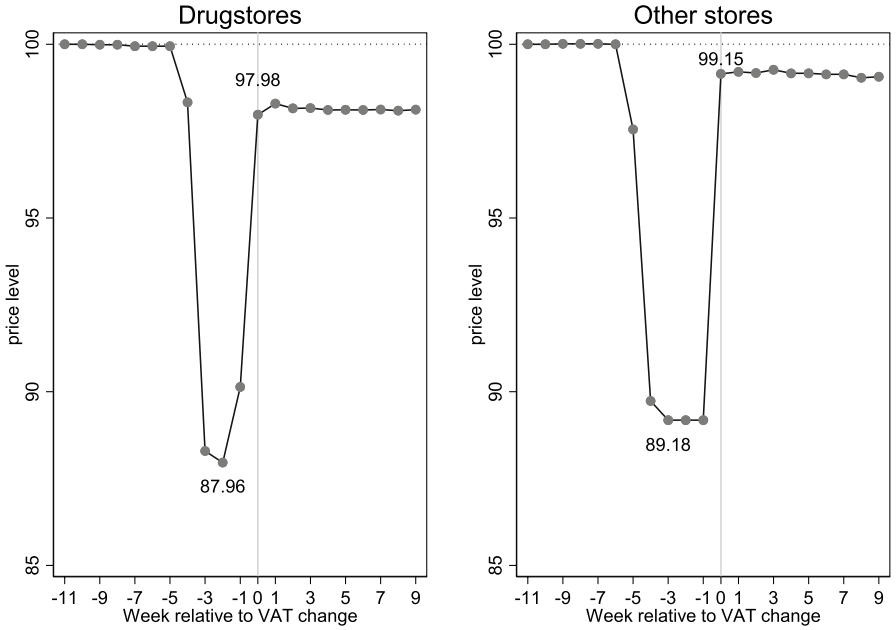

Fig. 8 This figures shows the normalized net price evolution over time separated by the store types. The graph on the left reflects the changes in net prices for drugstores while the graph on the right relates to other stores. $t = -5$ marks week number 48 in 2019 when the law was passed. $t = 0$ represents the first week of 2020 when the law came into effect. The price level is normalized to $t = -11$

The net price reduction for grocery stores is more than one percentage point lower than for drugstores. After the VAT change, the net prices of other stores remain one percentage point below drugstore prices.

B.3 Competition

We plot net prices over time by competition. Figure 9 shows net prices normalized to $t = -11$. The average change without competition between the passage of the law and the effective date of the VAT change was about 10.5 percentage points. The net price reduction after the VAT change takes effect varies between an excess pass-through of 0.5 percentage points and less than full pass-through.

Net prices for products with competition are reduced by about one percentage point more than for products without competition. After the reform, net prices for products with competition remain about 1.6 percentage points below the previous level.

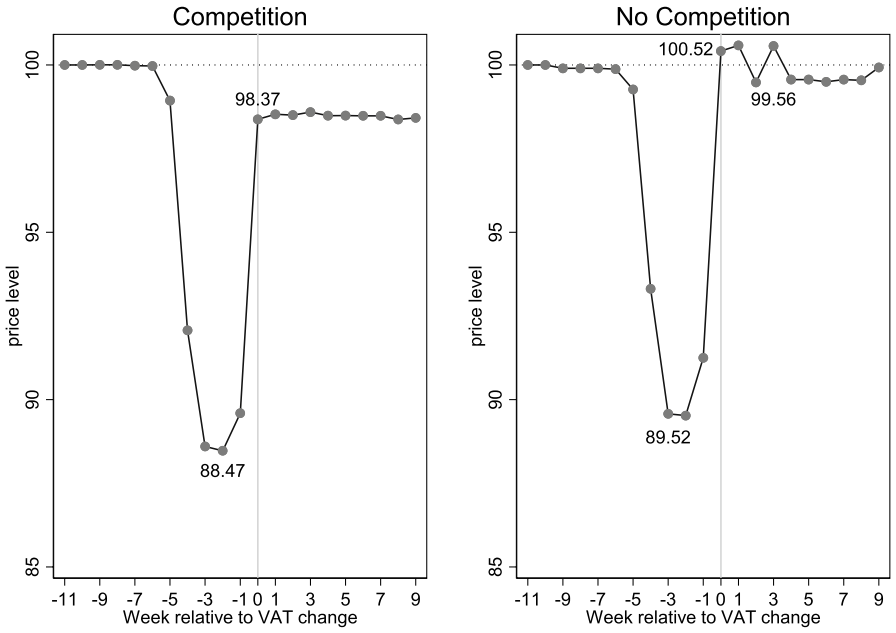

Fig. 9 This figure shows the normalized net price evolution over time, separated by competition. The graph on the left reflects the changes in net prices for products with competition, while the graph on the right refers to products without competition. $t = -5$ marks week number 48 in 2019, when the law was passed. $t = 0$ represents the first week of 2020, when the law went into effect. The price level is normalized to $t = -11$

Appendix C Supplementary regression results

C.1 Robustness

C.1.1 Number of retailers

We observe in total 10 different retailers on a largely weekly basis in our data. However, one of these 10 retailers is only observed in 2019w42 and 2020w4 which means there is no observation in the weeks declared as 'between' periods. Table 9 compares the results for 10 retailers and the results for the nine retailers when the retailer with fewer observations over time is excluded. We compare the specifications in the baseline regression and interacted with the product-type dummy variable. In both regressions, the baseline with or without retailer D and when the product type is included, we see very little difference between the data sets. Therefore, we decide to also include retailer D in the analyzed data.

C.1.2 Handling of week number 1

The turning of the year from 2019 to 2020 was a Tuesday to Wednesday. The official WN 1 in 2020 therefore started on Monday, December 30, 2019, which means WN 1 in the data set contains both the days when the applied VAT was still 19% and the days when the new VAT of 7% was applied. As a robustness check, we change WN 1 in 2020 to the 'between' period in the regressions presented in columns (3) and (4) of Table 10. In comparison to columns (1) and (2) in which WN 1 is specified

Table 9 Result comparison with and without retailer D

	10 Retailer		9 Retailer	
	= including D	+ product type	= excluding D	+ product type
Between	−0.114***	−0.124***	−0.114***	−0.124***
	(0.000562)	(0.000741)	(0.000580)	(0.000646)
After	−0.119***	−0.127***	−0.119***	−0.127***
	(0.000350)	(0.000548)	(0.000327)	(0.000519)
Between × tampon		0.0250***		0.0249***
		(0.00122)		(0.00112)
After × tampon		0.0181***		0.0180***
		(0.000602)		(0.000604)
Constant	1.031***	1.031***	1.032***	1.032***
	(0.00273)	(0.00271)	(0.00268)	(0.00268)
Retailer–Product FE	✓	✓	✓	✓
R^2	.9978904	.9980533	.9979253	.9980869
Observations	17015	17015	16921	16921

Bootstrapped standard errors in parentheses. This table shows the differences of the baseline estimation and the estimation including the product-type dummy (× tampon, × *tampon* presents the difference for tampons) with and without retailer D. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 10 Result comparison switching 2020w1 from 'after' to 'between'

	Baseline		Robustness check	
	2020w1 in 'after'	+ product type	2020w1 in 'between'	+ product type
Between	−0.114***	−0.124***	−0.115***	−0.125***
	(0.000573)	(0.000648)	(0.000504)	(0.000591)
After	−0.119***	−0.127***	−0.119***	−0.127***
	(0.000318)	(0.000470)	(0.000316)	(0.000470)
Between × tampon		0.0250***		0.0239***
		(0.00115)		(0.000996)
After × tampon		0.0181***		0.0180***
		(0.000542)		(0.000544)
Constant	1.031***	1.031***	1.031***	1.031***
	(0.00274)	(0.00274)	(0.00274)	(0.00274)
Retailer–Product FE	✓	✓	✓	✓
R^2	.9978904	.9980533	.9978859	.9980481
Observations	17015	17015	17015	17015

Bootstrapped standard errors in parentheses. This table shows the differences of the baseline estimation and the estimation including the product-type dummy (× tampon, × *tampon* presents the difference for tampons) when 2020w1 is in ''after' or in 'between'. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

as 'after', the observed effect changes accordingly. We compare the specifications in the baseline regression and interacted with the product-type dummy variable. We choose the specification when WN 1 is included in the 'after' period as the majority of days in WN 1 belong to the year 2020 when the new VAT rate is applied.

C.1.3 Handling of week number 48

The law was passed on November 29, a Friday in WN 48 in 2019. This means that WN 48 could also be included in the anticipation period captured by the *between* dummy variable in our regressions. The treatment of this week also affects our estimate of the *after* price reduction, as it affects the definition of the period before the law was passed. Table 11 shows the comparison for the baseline regression and interacted with the product-type dummy variable. As a robustness check, we change WN 48 in 2019 to the 'between' period in the regressions shown in columns (3) and (4) of Table 11. Compared to columns (1) and (2), where WN 48 is specified as 'before', the observed effect changes accordingly. We choose the specification where WN 48 is included in the pre-reform period because the majority of days in WN 48 are before the official passage of the law. This is therefore the more cautious approach.

C.1.4 Rounding and timing

The pricing strategy of "rounding to the preferred decimals" can explain most of the excess pass-through observed in the data. Table 12 shows that the probability of using this strategy is not strongly affected by the reform. In fact, we find that a

Table 11 Result comparison switching 2019w48 from 'between' to 'before'

	Baseline		Robustness check	
	2019w48 in 'before'	+ product type	2019w48 in 'between'	+ product type
Between	-0.114^{***}	-0.124^{***}	-0.0892^{***}	-0.0994^{***}
	(0.000573)	(0.000648)	(0.000939)	(0.00125)
After	-0.119^{***}	-0.127^{***}	-0.121^{***}	-0.129^{***}
	(0.000318)	(0.000470)	(0.000326)	(0.000454)
Between × tampon		0.0250^{***}		0.0242^{***}
		(0.00115)		(0.00181)
After × tampon		0.0181^{***}		0.0200^{***}
		(0.000542)		(0.000544)
Constant	1.031^{***}	1.031^{***}	1.033^{***}	1.033^{***}
	(0.00274)	(0.00274)	(0.00273)	(0.00273)
Retailer–Product FE	✓	✓	✓	✓
R^2	.9978904	.9980533	.9948947	.9950632
Observations	17015	17015	17015	17015

Bootstrapped standard errors in parentheses. This table shows the differences of the baseline estimation and the estimation including the product-type dummy (× tampon, × *tampon* presents the difference for tampons) when 2019w48 is in ''before' or in 'between'. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 12 Rounding and timing

	Rounding preferred second decimal
Between	0.0197^{***}
	(0.00256)
After	0.0189^{***}
	(0.00230)
Constant	0.973^{***}
	(0.00214)
Retailer–Product FE	✓
R^2	.1074017
Observations	17015

Bootstrapped standard errors in parentheses. This table shows the probability of prices ending with one of the preferred second decimals (0, 5, or 9) for the *between* and *after* phase relative to the *before* period using a Linear Probability Model. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

total of 98.5% of the observed prices end with one of the preferred second decimal places. Before the law was passed and after the reform took effect, the proportions of prices ending in 0, 5, or 9 are 97.39% (before) and 99.21% (after). We consider

the significant but small difference between the two periods to be negligible for causality attribution given the size of the shares.

C.1.5 Fixed effects

In Table 13 we contrast our baseline regression for different fixed effects. The coefficients presented are 'between' for the expected price decrease and 'after' capturing the price decrease after the VAT change took effect. Column (1) presents the result without controlling for any time-invariant fixed effects. Retailer fixed effects are introduced in column (2) to control for time-constant characteristics of the observed retailers. Column (3) reports the results when time-constant product characteristics are included. Comparing these columns, we see that much of the variation within the panel can be captured when controlling for the time-constant product characteristics. In our analysis, we have controlled for retailer and product fixed effects, which accounts for variation in both the retailer and product dimensions and controls for a large portion of the time-constant variation within our panel. This regression result from our baseline regression is shown in column (5).

Table 13 Comparison baseline for different fixed effects

	No FE	Retailer FE	Product FE	Retailer FE & Product FE	Retailer–Product FE
	(1)	(2)	(3)	(4)	(5)
Anticipated price drop:					
Between	-0.112^{***}	-0.126^{***}	-0.114^{***}	-0.114^{***}	-0.114^{***}
	(0.00870)	(0.00820)	(0.000586)	(0.000556)	(0.000562)
Effective date:					
After	-0.127^{***}	-0.128^{***}	-0.119^{***}	-0.119^{***}	-0.119^{***}
	(0.00682)	(0.00647)	(0.000381)	(0.000361)	(0.000350)
Constant	1.035^{***}	1.037^{***}	1.031^{***}	1.031^{***}	1.031^{***}
	(0.00496)	(0.00474)	(0.00270)	(0.00270)	(0.00273)
Retailer FE	×	✓	×	✓	×
Product FE	×	×	✓	✓	×
Retailer–Product FE	×	×	×	×	✓
R^2	.0249888	.1238924	.9971255	.997395	.9978904
R^2 (within)	.0249888	.0291289	.8878652	.8967115	.9146051
Observations	17015	17015	17015	17015	17015

Bootstrapped standard errors in parentheses. This table shows the differences of the baseline estimation for different fixed effects. *between* captures the price reduction due to the anticipatory effect; *after* shows the price reduction after the VAT change. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

C.1.6 Comprehensive regression analysis

In the previous sections, we separately identified the product type, the store type, and the number of retailers offering a product as having a significant effect on the pass-through rate. Since we analyze these effects separately, questions about their joint significance arise. Table 14 combines all these effects in column (4). We find all added effects are relevant and significant.

C.2 Rounding down

In comparison to Sect. 5.4, we now condition on rounding down to the same second decimals. Table 15 provides descriptive insights into the competitive segments. The regression results presented in Table 16 show the impact of store type, product type,

Table 14 Comprehensive regression

	Base (1)	+ Product type (2)	+ Drugstore (3)	+ Competition (4)
Between	-0.114^{***}	-0.124^{***}	-0.119^{***}	-0.105^{***}
	(0.000573)	(0.000648)	(0.000764)	(0.00197)
After	-0.119^{***}	-0.127^{***}	-0.118^{***}	-0.107^{***}
	(0.000318)	(0.000470)	(0.000479)	(0.000972)
Between × tampon		0.0250^{***}	0.0253^{***}	0.0261^{***}
		(0.00115)	(0.00115)	(0.00115)
After × tampon		0.0181^{***}	0.0185^{***}	0.0192^{***}
		(0.000542)	(0.000541)	(0.000561)
Between × drugstore			-0.0102^{***}	-0.00869^{***}
			(0.00104)	(0.00111)
After × drugstore			-0.0149^{***}	-0.0135^{***}
			(0.000598)	(0.000611)
Between × competition				-0.0159^{***}
				(0.00223)
After × competition				-0.0136^{***}
				(0.00112)
Constant	1.031^{***}	1.031^{***}	1.031^{***}	1.031^{***}
	(0.00274)	(0.00274)	(0.00274)	(0.00274)
Retailer–Product FE	✓	✓	✓	✓
R^2	.9978904	.9980533	.9981332	.9981552
R^2 (within)	.9146051	.9211977	.9244321	.9253225
Observations	17015	17015	17015	17015

Bootstrapped standard errors in parentheses. *between* and *after* show the price reduction as in the baseline regression; × *tampon* adds the product-type differentiation into the regression; × *competition* adds the competition effect to the regression; × *drugstore* compares for drugstores and other stores. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 15 Rounding and Heterogeneities

(1)			(2)			(3)		
Product type × Rounding			Store type × Rounding			Competition × Rounding		
	Freq.	Percent		Freq.	Percent		Freq.	Percent
Sanitary pads			No drugstore			No competition		
Rounding = 0	57	10.86	Rounding = 0	123	29.78	Rounding = 0	14	19.72
Rounding = 1	468	89.14	Rounding = 1	290	70.22	Rounding = 1	57	80.28
Total	525	100	Total	413	100	Total	71	100
Tampons			Drugstore			Competition		
Rounding = 0	68	17.62	Rounding = 0	2	0.40	Rounding = 0	111	13.21
Rounding = 1	318	82.38	Rounding = 1	496	99.60	Rounding = 1	729	86.79
Total	386	100	Total	498	54.67	Total	840	100
Total			Total			Total		
Sanitary pads	525	57.63	No drugstore	413	45.33	No competition	71	7.794
Tampons	386	42.37	Drugstore	498	54.67	Competition	840	92.21
Total	911	100	Total	911	100	Total	911	100

This table shows descriptive insights into the heterogeneities in the 'Total' row and descriptive insights within the competitive segments conditioned on whether retailers consistently round down

and retailer competition for the same condition. We restricted the sample to those with more than a full pass-through, allowing us to identify differences in competitive segments based on the rounding strategy.

Column (1) of Table 16 contains the product-type heterogeneity, while Table 15 column (1) shows the number of observations for the two product types differentiated by rounding. We observe that relatively more sanitary pad products round to the same decimal place than tampon products. Similarly, the regression results show a highly significant higher price reduction for sanitary pads than for tampons when both round *after* the VAT change.[34] This finding is consistent with the results from Sect. 4.2.1, which also show a larger reduction for sanitary pads.

The second column of Table 16 presents the store-type heterogeneity. Nearly all drugstore products are rounded to the same second decimal while 30% of other store products are not. The regression results indicate that drugstores reduce their prices highly significantly more than other stores given both round.[35]

The competition heterogeneity is included in column (3) of Table 16. Table 15 column (3) shows the number of observations with and without competition differentiated by rounding. We can see that relatively more observations with competition rounded compared to those without competition. This is also reflected in the regression results as we see highly significantly more price reduction with competition given both round.

[34] We estimate the difference by adding *after* × *tampon* and *after* × *rounding* × *tampon*. The estimated difference is approximately 2.3 percentage points after the VAT change.

[35] The estimated difference is around 1.3 percentage points after the VAT change.

Table 16 Products rounding with constant second decimal given excess pass-through interacted with

	+ Product Type	+Store type	+Competition
	ln(price)	ln(price)	ln(price)
Between	−0.102***	−0.111***	−0.104***
	(0.00127)	(0.000662)	(0.00146)
After	−0.105***	−0.112***	−0.102***
	(0.000882)	(0.000520)	(0.00153)
Between × rounding	−0.0258***	0.00296**	−0.00333
	(0.00144)	(0.000977)	(0.00256)
After × rounding	−0.0250***	0.000646	−0.00814***
	(0.00104)	(0.000658)	(0.00196)
Between × tampon	−0.0143***		
	(0.00155)		
After × tampon	−0.0118***		
	(0.000912)		
Between × rounding × tampon	0.0442***		
	(0.00211)		
After × rounding × tampon	0.0342***		
	(0.00113)		
Between × drugstore		0.0548	
		(0.0410)	
After × drugstore		0.00296***	
		(0.000520)	
Between × rounding × drugstore		−0.0691	
		(0.0411)	
After × rounding × drugstore		−0.0189***	
		(0.000837)	
Between × competition			−0.00735***
			(0.00150)
After × competition			−0.0115***
			(0.00149)
Between × rounding × competition			−0.00316
			(0.00259)
After × rounding × competition			−0.00135
			(0.00199)
Constant	1.048***	1.048***	1.048***
	(0.00275)	(0.00281)	(0.00275)
Retailer–Product FE	✓	✓	✓
R^2	.9982832	.998155	.9980903
Observations	16083	16083	16083

Bootstrapped standard errors in parentheses. This table shows the different heterogeneities interacted with a dummy identifying prices with rounding to a consistent second decimal (× rounding) given excess pass-through. In column (1) *between* and *after* show the price reduction for sanitary pads; × *tampon* presents the difference for tampons. In column (2) *between* and *after* show the price reduction for other stores; × *drugstore* presents the difference for drugstores. In column (3) *between* and *after* show the price reduction without competition; × *competition* presents the difference with competition. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

C.3 Retailer

Disaggregating the data by retailers, Table 17 shows that all retailers except retailer D[36] reduced their prices by at least the amount or even more than the VAT reduction would suggest. Retailers C and J reduced their gross prices by more than one percentage point more than most other competitors. Also, retailer E was above the average reduction in Table 17. Table 18 adds a robustness check as it shows that the results are largely the same for all retailers.

Table 19 also shows differences in the pricing reactions of the retailers concerning the LMB and other brands. Retailer C reduced the prices, on average, by 1.84 percentage points more if the product was from the LMB while retailers A and B reduced other brands' products more than the LMB products.

C.4 Number of retailers

Table 20 upper part presents the results when we take the number of retailers (denoted by #) stocking a same given product into account. Because the data set does not comprise the complete supply side, this number has to be interpreted as a proxy for the true number of retailers.

The first column in Table 20 upper part shows the average relative price reduction for products offered at just one retailer in the data set. The relative price reduction of 10.07% is not significantly different from the benchmark of 10.084%.[37] The other columns of Table 20 upper part show that if there is at least one competitor also stocking the same product, the VAT reduction is stronger. The sum of coefficients for 'between' and 'after' is significantly different from the benchmark of 10.084%.

Table 20 lower part presents the relative price effects for different numbers of retailers offering the product with a type dummy variable. The positive sign of the 'between × tampon' coefficients for two or more retailers supports the finding of stronger effects for sanitary pads from Sect. 4.2.1.

C.5 Size and packsize

There are various sizes and packages for both product types. The most frequently offered tampon size is "normal" followed by the size "super", then the less often supplied "super plus" and with some more distance "mini". The normal size is mostly sold in packs of 16, as is the super size. Around 35% of all packages stocked include 16 tampons. The share of normal size tampons in a pack of 16 is 14.5% among all tampon products in our data set and this is the most frequently offered tampon package.

In the sanitary pads segment, most of the products have "wings" and are followed by the "normal" sized sanitary pads. Whereas the sanitary pads with wings are

[36] Retailer D is only observed before and after the VAT change, but not in our 'between' period.

[37] The benchmark of a 10.084% price reduction corresponds to a regression coefficient of −0.1063.

Table 17 Price effects for different retailers using retailer–product fixed effects

	Retailer									
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
Between	− 0.109***	− 0.117***	− 0.116***		− 0.118***	− 0.0856***	− 0.0856***	− 0.0863***	− 0.116***	− 0.133***
	(0.000428)	(0.000259)	(0.00188)		(0.00249)	(0.00760)	(0.00760)	(0.0103)	(0.000268)	(0.00247)
After	− 0.109***	− 0.117***	− 0.131***	− 0.0955***	− 0.123***	− 0.114***	− 0.114***	− 0.115***	− 0.116***	− 0.134***
	(0.000406)	(0.000227)	(0.000838)	(0.0134)	(0.00158)	(0.000967)	(0.000967)	(0.00124)	(0.000277)	(0.00197)
Constant	0.997***	1.026***	0.937***	0.921***	0.936***	1.314***	1.314***	1.306***	1.299***	1.170***
	(0.00586)	(0.00534)	(0.00498)	(0.0526)	(0.0149)	(0.00485)	(0.00485)	(0.00502)	(0.00173)	(0.0124)
Retailer–Product FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R^2	.9992449	.9997805	.9949568	.9930878	.9979056	.9421968	.9421968	.9420741	.9982031	.9971784
Observations	5010	3639	4423	94	890	189	189	168	1638	775

Bootstrapped standard errors in parentheses. This table shows the heterogeneity of price changes between retailers both in the anticipation period and after the actual VAT change. *between* captures the price reduction due to the anticipatory effect; *after* shows the price reduction after the VAT change. Retailers are anonymized using letters A to J. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 18 Price effects for different retailers using retailer–product fixed effects

	Retailer	
	(1)	
Between	−0.109***	(0.000508)
After	−0.109***	(0.000468)
A	0	(0)
B × between	−0.00806***	(0.000551)
C × between	−0.00719***	(0.00208)
E × between	−0.00930***	(0.00229)
F × between	0.0232**	(0.00847)
G × between	0.0232**	(0.00829)
H × between	0.0225*	(0.00985)
I × between	−0.00707***	(0.000559)
J × between	−0.0238***	(0.00250)
B × after	−0.00785***	(0.000504)
C × after	−0.0214***	(0.00112)
D × after	0.0138	(0.0119)
E × after	−0.0137***	(0.00169)
F × after	−0.00486***	(0.00113)
G × after	−0.00486***	(0.00103)
H × after	−0.00577***	(0.00113)
I × after	−0.00662***	(0.000549)
J × after	−0.0248***	(0.00211)
Constant	1.031***	(0.00273)
Retailer–Product FE	✓	
R^2	.9980462	
Observations	17015	

Bootstrapped standard errors in parentheses. This table shows the majority of retailers' price changes was significantly different both in the anticipation period and after the actual VAT change. *between* captures the price reduction due to the anticipatory effect; *after* shows the price reduction after the VAT change. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

mainly offered in a pack of 18 the normal size sanitary pads are sold in a 14 pack. Although the differentiation within the technologies is limited, there is a rich variety of size and package size combinations.

We analyze the pass-through also with respect to different products within the two product groups. In Table 21 upper part, columns (2) and (3) show that the relative price reductions for the two sanitary pad types offered most in the data are smaller than the reduction at the aggregated level, but they exceed the benchmark of 10.084%.

Columns (6) and (7) show the two most frequently offered combinations of size and package size for sanitary pads. With relative price reductions of 11.32% and

Table 19 Price effects for different retailers including LMB dummy variable using retailer–product fixed effects

	Retailer									
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
Between	−0.115***	−0.127***	−0.0898***		−0.113***	−0.0856***	−0.0856***	−0.0863***	−0.116***	−0.117***
	(0.00213)	(0.00178)	(0.00721)		(0.00547)	(0.00760)	(0.00760)	(0.0103)	(0.000268)	(0.00182)
Between × LMB	0.00593**	0.0112***	−0.0285***		−0.00648					−0.0226***
	(0.00219)	(0.00178)	(0.00744)		(0.00541)					(0.00384)
After	−0.115***	−0.130***	−0.113***	−0.0690	−0.124***	−0.114***	−0.114***	−0.115***	−0.116***	−0.122***
	(0.00207)	(0.00131)	(0.00241)	(0.0500)	(0.00324)	(0.000967)	(0.000967)	(0.00124)	(0.000277)	(0.00159)
After × LMB	0.00546*	0.0140***	−0.0189***	−0.0355	0.00174					−0.0177***
	(0.00215)	(0.00134)	(0.00254)	(0.0501)	(0.00351)					(0.00348)
Constant	0.997***	1.026***	0.937***	0.921***	0.936***	1.314***	1.314***	1.306***	1.299***	1.170***
	(0.00586)	(0.00534)	(0.00498)	(0.0530)	(0.0149)	(0.00485)	(0.00485)	(0.00502)	(0.00173)	(0.0123)
Retailer–Product FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R^2	.9992461	.999808	.9950227	.9934743	.9979153	.9421968	.9421968	.9420741	.9982031	.9973022
Observations	5010	3639	4423	94	890	189	189	168	1638	775

Bootstrapped standard errors in parentheses. This table shows the heterogeneity of price changes between retailers both in the anticipation period and after the actual VAT change differentiated by LMB and other brands. *between* captures the price reduction due to the anticipatory effect; *after* shows the price reduction after the VAT change. × LMB presents the difference for the leading manufacturer brand (LMB). $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 20 Price effects by number of retailers offering the product

	Retailer								
	(#1)	(#2)	(#3)	(#4)	(#5)	(#6)	(#7)	(#9)	(#10)
Between	− 0.101***	− 0.114***	− 0.122***	− 0.113***	− 0.132***	− 0.123***	− 0.0959***	− 0.102***	− 0.0977***
	(0.00207)	(0.00108)	(0.00143)	(0.000784)	(0.00312)	(0.00205)	(0.00384)	(0.00421)	(0.00318)
After	− 0.106***	− 0.116***	− 0.127***	− 0.116***	− 0.136***	− 0.128***	− 0.106***	− 0.117***	− 0.113***
	(0.00108)	(0.000866)	(0.000898)	(0.000276)	(0.00231)	(0.00122)	(0.00140)	(0.000654)	(0.000527)
Constant	1.293***	0.760***	0.752***	1.241***	0.839***	0.938***	1.374***	1.280***	1.329***
	(0.0123)	(0.00654)	(0.00379)	(0.00297)	(0.00923)	(0.0107)	(0.000867)	(0.00258)	(0.00178)
Retailer–Product FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
R^2	.9980455	.9979896	.993637	.9973693	.9934397	.9979359	.9184223	.9667544	.9680043
Observations	1276	2400	4173	5354	519	1313	363	519	1098
	Retailer								
	(#1)	(#2)	(#3)	(#4)	(#5)	(#6)	(#7)	(#9)	(#10)
Between	− 0.105***	− 0.116***	− 0.149***	− 0.120***	− 0.134***	− 0.143***	− 0.0959***	− 0.105***	− 0.105***
	(0.00233)	(0.00106)	(0.00167)	(0.000426)	(0.00401)	(0.00337)	(0.00384)	(0.00572)	(0.00494)
Between × tampon	0.0156**	0.0182***	0.0517***	0.0193***	0.00462	0.0356***		0.00900	0.0112*
	(0.00530)	(0.00506)	(0.00224)	(0.00184)	(0.00604)	(0.00445)		(0.00925)	(0.00514)
After	− 0.110***	− 0.117***	− 0.150***	− 0.120***	− 0.139***	− 0.145***	− 0.106***	− 0.121***	− 0.121***
	(0.000666)	(0.000983)	(0.00164)	(0.000369)	(0.00273)	(0.00234)	(0.00140)	(0.000835)	(0.000896)
After × tampon	0.0184***	0.00781***	0.0423***	0.0105***	0.00991*	0.0314***		0.0125***	0.0130***
	(0.00351)	(0.00183)	(0.00166)	(0.000448)	(0.00447)	(0.00267)		(0.00120)	(0.000964)
Constant	1.292***	0.760***	0.752***	1.241***	0.839***	0.938***	1.374***	1.280***	1.329***
	(0.0123)	(0.00656)	(0.00376)	(0.00298)	(0.00923)	(0.0108)	(0.000867)	(0.00262)	(0.00179)

Table 20 (continued)

	Retailer								
	(#1)	(#2)	(#3)	(#4)	(#5)	(#6)	(#7)	(#9)	(#10)
Retailer–Product FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
R^2	.9981367	.9980275	.9951037	.9976403	.993524	.9982406	.9184223	.9676533	.9690486
Observations	1276	2400	4173	5354	519	1313	363	519	1098

Bootstrapped standard errors in parentheses. This table shows the price changes depending on the number of retailers in the anticipation period and after the actual VAT change (upper part) differentiated by product type (lower part). *between* captures the price reduction due to the anticipatory effect; *after* shows the price reduction after the VAT change. × *tampon* presents the difference for tampons. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 21 Price effects by size—sanitary pads and tampons

	Sanitary pads						
	(all types)	(wings)	(long)	(night)	(normal)	(wings#18)	(normal#14)
Between	−0.124***	−0.122***	−0.131***	−0.129***	−0.121***	−0.115***	−0.129***
	(0.000657)	(0.00107)	(0.00161)	(0.00178)	(0.00111)	(0.00231)	(0.00242)
After	−0.127***	−0.123***	−0.133***	−0.133***	−0.124***	−0.119***	−0.130***
	(0.000501)	(0.000969)	(0.00120)	(0.00134)	(0.000723)	(0.000557)	(0.00231)
Constant	0.949***	0.903***	0.969***	1.012***	0.945***	1.237***	0.565***
	(0.00369)	(0.00659)	(0.00873)	(0.00885)	(0.00883)	(0.000483)	(0.00241)
Retailer–Product FE	✓	✓	✓	✓	✓	✓	✓
R^2	.9977463	.9976731	.9969444	.9965979	.9986787	.9678667	.9051015
Observations	9895	3112	1915	1744	2594	656	571
	Tampons						
	(all types)	(mini)	(normal)	(super)	(superplus)	(normal#16)	(super#16)
Between	−0.0994***	−0.0973***	−0.0959***	−0.104***	−0.0987***	−0.0943***	−0.0943***
	(0.00109)	(0.00309)	(0.00191)	(0.00130)	(0.00200)	(0.00300)	(0.00300)
After	−0.109***	−0.108***	−0.109***	−0.109***	−0.108***	−0.108***	−0.108***
	(0.000313)	(0.000612)	(0.000507)	(0.000635)	(0.000595)	(0.000883)	(0.000883)
Constant	1.146***	1.073***	1.055***	1.061***	1.309***	0.737***	0.737***
	(0.00412)	(0.0127)	(0.00693)	(0.00764)	(0.00380)	(0.00476)	(0.00476)
Retailer–Product FE	✓	✓	✓	✓	✓	✓	✓
R^2	.9981577	.9986113	.9980311	.9984727	.9914836	.989437	.989437
Observations	7120	865	2184	1863	1295	1097	1097

Bootstrapped standard errors in parentheses. This table shows the price changes of different sizes for sanitary pads (upper part) and tampons (lower part) including the most frequent combinations of size#packsize. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

12.74% they are also significantly above the benchmark (for (6) $p = 0.01$ and for (7) $p = 0.05$).

For the tampon technology, Table 21 lower part shows a quite homogeneous price reduction for all types and also for the two most frequently offered combinations of size and package size.

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