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ORIGINAL ARTICLE

The impact of sweet food tax on producers and household spending—Evidence from Hungary

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Abstract

Since 2011, a wide range of unhealthy food and drink are subject to a specific excise tax in Hungary. We analyze how this tax affected the revenue, sales volume, personnel costs, and size of sweet food producers, and compare these results to estimated effects on household spending on sugary food. We base our analysis on administrative data sets of firm level indicators, and survey data on household spending. We apply the estimation method of difference-in-differences, where firms producing untaxed processed food (in the firm level analysis) and household spending on food categories directly not affected by the tax (in the household level analysis) serve as control groups. Our results suggest strong negative short-run effects of the unhealthy food tax on firms' inland sales volume, and moderate effects on inland sales revenue and personnel costs. These results correspond to the moderate estimated effects on household spending on sugary food. The reducing effects diminish in about 3 years after the introduction of the tax—overlapping with the recovery of the Hungarian economy from recession. Our findings suggest that the impacts of an unhealthy food tax strongly depend on the economic conditions.

KEYWORDS
difference-in-differences, household spending, Hungary, sugar tax, sweet food production

JEL CLASSIFICATION
H20, D12, D22

1 | INTRODUCTION

Unhealthy food and drink taxes have been implemented or are considered as a potential policy in several countries around the world (Smith et al., 2018; Teng et al., 2019). The general aims of such taxes are to improve population health and generate public revenues at the same time. Hungary is a leading country in the application of such taxes: a wide range of processed food and drinks rich in sugar, salt, or other potentially unhealthy ingredients are subject to a specific excise tax since 2011. The tax is collected from the firm that first sells the taxable product in Hungary and the amount of the tax is determined per unit of the product sold. Despite its almost 10-year history in Hungary, relatively little is known about the effect of the tax on the food and drink industry, consumption patterns, and population health. Our aim in this article is to provide empirical evidence on how the unhealthy food tax affected the producers of sugary food up to 5 years after the introduction of the tax. We complement this evidence with results on household level spending on sugary food up to 3 years after the introduction of the tax.

There is evidence in the literature from different countries that unhealthy food and drink taxes tend to reduce the consumption of the targeted (unhealthy) products in the short run. Bíró (2015), National Institute for Health Development (2013), and World Health Organization (2015) find such evidence for the short-term effects of the junk food tax in Hungary. Batis et al. (2016) find reducing effects on the consumption of energy-dense food 1 year after the introduction of unhealthy food and drink tax in Mexico. Smed et al. (2016) estimate that the Danish fat tax reduced the intake of saturated fat within 1 year, albeit they also conclude that the saturated fat tax made a minor contribution to public health in Denmark. Redondo et al. (2018) conduct a systematic review of studies evaluating the impact of taxes on sugar sweetened beverages in the U.S. and Mexico, and conclude that such taxes have the potential to reduce calorie and sugar intake. Teng et al. (2019) arrive at a similar conclusion based on the analysis of 17 studies that estimate the impact of sugar sweetened beverage taxes. On the other hand, Capacci et al. (2019) find little evidence that the French tax on sweetened non-alcoholic drinks reduced consumption. Otherwise, the literature mainly relies on simulation studies to investigate the potential impact of unhealthy food and drink taxes. It is beyond the scope of this paper to provide a review of the entire simulation-based literature. As a summary, most of the studies find that taxing unhealthy food and drinks can lead to dietary improvements and higher public revenues (Caro et al., 2017; Cornelsen et al., 2019; Harding & Lovenheim, 2017, among many others). Other papers point out the regressive nature of taxes on unhealthy food and drinks (Allais et al., 2010; Sacks et al., 2011; Zhen et al., 2014), although Allcott et al. (2019) claim that stronger preferences for redistribution can increase the optimal sin tax, if lower-income consumers are more responsive to taxes or are more biased. Cornelsen et al. (2019) also find that as a result of unhealthy food tax, the dietary quality of the purchases of households in low socio-economic status generally improved the most. There are also papers that emphasize the combination of taxes with other policy interventions, such as subsidies or labeling, to achieve the health policy aims (Caro et al., 2020; Tiffin & Arnoult, 2011).

Our main contribution to the literature is the analysis of how the unhealthy food tax affects the producers. If the tax achieves its aims and the consumption of the unhealthy food declines then that likely hits the affected food industry negatively, in the sense that sales volumes and revenues might fall. However, the effects depend on the price elasticity of demand. Also, it is not clear how the producers react to the taxation—the tax might not only affect the pricing strategy of firms; the producers can also change their product composition so as to minimize the impact of the tax on the firm's performance. The size of the firms might also decrease as a consequence of the tax, due to lay-offs, necessitated by reduced sales volumes. Firms might also decide to cut wages, hence reduce personnel costs, to partly compensate for the loss in revenues. Understanding the effects of the tax on producers is necessary for obtaining a full picture of the economic consequences of unhealthy food taxes. A related line of the literature consists of papers that look at the effect of unhealthy food and drinks tax on prices. Berardi et al. (2016) find that the French soda tax was shifted to the price of sugary drinks, albeit the magnitude of the pass-through was heterogeneous. Falbe et al. (2015), Silver et al. (2017) also find evidence for partial pass-through of soda tax to retail prices in Berkeley, California. Grogger (2017) finds that after the introduction of the soda tax in Mexico, soda prices rose by more than the amount of the tax. While understanding the price effects is important for understanding how unhealthy food and drinks taxes affect consumption, such analyses do not provide direct evidence on the impact of the tax on producers.

To the best of our knowledge, the only related study that analyzes the impact of the Hungarian unhealthy food tax on producers is the National Institute for Health Development (2013), based on survey data of 69 producers. Our analysis, on the other hand, covers a longer time period (2008-2016) and is based on administrative data of the universe of firms registered in Hungary. The rich set of data makes it possible to apply the method of difference-in-differences to analyze the impact of the tax on firms, to analyze if and how the impact changed over time, particularly after the recovery of the economy from the crisis, and to compare the estimated effects with the impact on household purchases.

2 | POLICY BACKGROUND

Unhealthy food and drinks are subject to a specific tax since September 2011 in Hungary. Already in February 2011, the government announced the plan of levying tax on food and drink rich in sugar or salt. Then, in June 2011, the government decided to introduce the tax, which then came into effect in September 2011. A wide range of food and drinks are taxed, as displayed on Figure 1 (see Bíró, 2015 for further details on the taxed products). This is a specific tax, the amount of the tax is defined per unit of the product sold, measured either in kg or L. The tax is levied on the firm that first sells the taxable product in Hungary. This is the producer if the product is produced and sold in Hungary; and the importer if it is an imported good. If the product is exported then the tax does not apply. Focusing on sugary food, such goods are taxable which have at least 25% sugar content. If it is a product with cocoa then the tax applies if the cocoa content is below 40% and the

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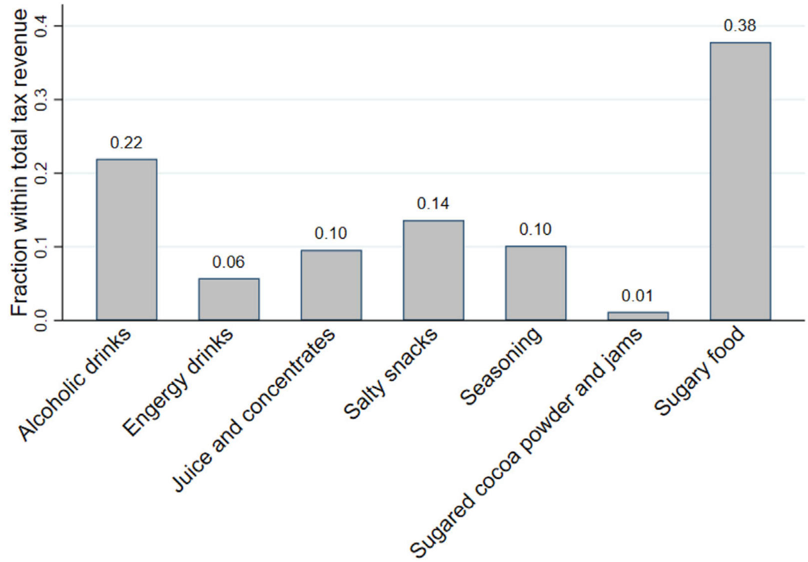

FIGURE 1 Distribution of unhealthy food and drink tax revenue by product categories, 2011–2018 (source: National Tax and Customs Administration of Hungary) [Color figure can be viewed at wileyonlinelibrary.com]

sugar content is above 40%. Note, that the tax applies only to pre-packed sugary food. Sugar itself is not taxed. In 2011, the tax rate was 100 HUF per 1 kg of sugary food. Between 2012 and 2018, the tax rate was 130 HUF per 1 kg of sugary food (130 HUF ≈ 0.43 USD).

Figure 1 shows that over years 2011–2018, 38% of the total unhealthy food and drink tax revenue originated from the production and sales of sugary food—the product category which is in the focus of this article. Relatively little tax income originated from jams. 600 HUF per 1 kg tax applies to jams, however, only to products with sugar content above 35% and which are not considered as premium products (premium jams typically have a fruit content above 60%). Producers of jams could therefore either reduce the sugar content or increase the fruit content so as to avoid the tax.

Both the tax base of and tax income from sugary food increased throughout years 2011–2018. According to statistics provided by the National Tax and Customs Administration of Hungary, the pre-packed sugary food tax base was 92 million kg in 2018, the pre-packed sugary food tax revenue was 12 billion HUF (≈ 40 million USD) in 2018.

3 | DATA

Throughout the article, we focus on the effect of the unhealthy food tax on the producers of sugary food and household spending on sugary food. This is partly a data driven choice, since sugary food is the food category affected by the tax which we can most reliably identify based on the available firm level and household level data. We exclude soft drinks from the analysis because we cannot observe the sugar and fruit content (or other ingredients) of the products, thus we cannot separate the taxed and untaxed drinks in our data.

3.1 | Firm level data

We use two administrative, anonymized, firm level annual panel datasets of the Hungarian Central Statistical Office.[1] The two datasets are linked through the same set of anonymized firm identifiers. The first dataset includes the annual balance sheet and income statement of all firms with double-entry bookkeeping registered in Hungary. The second dataset provides data on the product composition and sales of firms. We use data from 2008 until 2016, which is the latest available year. Thus, we have three full years of observations before the enforcement of the unhealthy food tax and 5 years of observations after. In the following, we treat year 2011 as treatment year because the tax was introduced in September 2011, thus could impact the outcomes of year 2011. Also, since plans of the tax were already known since February 2011, the firms could amend their production or sales strategies even before the tax became effective.

Using the primary industry codes of firms (NACE codes), we restrict the sample to food producers. Producers of soft drinks and alcoholic drinks are excluded from the analysis. Then, we create two subgroups within the food producers. A firm belongs to the treatment group—firms most likely affected by the unhealthy food tax—if its primary industry code is sweet food production (NACE class: manufacture of cocoa, chocolate and sugar confectionery). The control group consists of the rest of the food producers, excluding producers of sauces and condiments, and

[1] The firm level and household level datasets used in this article are available at the secure research room of the Hungarian Central Statistical Office and the Centre for Economic and Regional Studies. The calculations and the conclusions within the document are the intellectual product of the author, those do not reflect the opinion of the Hungarian Central Statistical Office.

producers of sweet bakery products. The rationale for these exclusions is to reduce the chance that some firms that are in fact affected by the unhealthy food tax are grouped to the control group. Nevertheless, it is still likely that some firms affected by the unhealthy food tax are allocated to the control group. Such misclassification error implies that all our estimates will be lower bounds of the true effects. In 2016, we have 46 firms in the treatment group and 905 firms in the control group. There are both entries and exits throughout years; each year, about 10% to 20% of firms drop out from our sample (including mergers and acquisitions).

Using the product composition dataset, we analyze the following variables as outcome variables, applying the inverse hyperbolic sine transformation, abbreviated as *asinh*, henceforth[2]: net revenue from sales in Hungary; net revenue from export sales; sales volume in Hungary; export sales volume. We analyze two additional outcomes without the *asinh* transformation: the share of export in sales volume, and the binary indicator if the firm had any export revenue in a given year. When analyzing the sales volume, we keep only those observations where the volume is measured in tons or kilograms (and not in L), and rescale the volume to tons.

Using the data on balance sheet and income statement, we analyze the following variables as outcome variables, applying the inverse hyperbolic sine (*asinh*) transformation: personnel expenditure (including gross wages, gross salaries, and social security payments); number of workers at the firm.

We winsorize all firm level outcome variables at 99%. Also, we deflate all monetary outcomes (revenue and expenditure measures) to year 2008.

For heterogeneity analyses, we generate a binary indicator if the firm has at most 50 versus more than 50 workers, and an indicator if the firm has any export activity or not.

Table 1 shows that on average (using data from 2008–2016), sweet food producers have lower sales revenue and volume than firms in the control group (other food producers). Firms in the treatment group are also somewhat smaller, on average, but are more likely to have export activities. The lower panel of the table indicates that smaller firms are, on average, less likely to have export activities both in the treatment and control group.

Figure 2 shows the time patterns of inland and export sales revenue and volume of sweet food producers and other food producers. The plots suggest marked increase in export sales of sweet food producers around and after the introduction of the unhealthy food tax and a smaller relative decline in inland sales volumes. In our empirical analysis, we net out firm characteristics and time effects to estimate the effects of the tax (see Section 4).

3.2 | Household level data

We use the Hungarian Household Budget and Living Conditions Survey (HBLCS) to estimate the impact of the unhealthy food tax on spending on sugary food products. The survey is administered by the Hungarian Central Statistical Office. Around 8.5 thousand households are covered annually in a rotational panel, with one third of the households rotating annually. The sample is representative for the Hungarian population, excluding the institutionalized people. Each household is asked to keep a diary of purchases for one month. Each month, a randomly drawn twelfth of the households run a diary. The month of the diary is not included in the dataset. Nevertheless, this sample construction implies that in year 2011, one third of the households report purchases in a period when the unhealthy food tax was already in place.

We use data from years 2008–2014. Due to a methodological change, the consumption data (consumption categories) from years 2015–2016 cannot be made comparable to the earlier years, thus we cannot include the last two available years in the analysis. We use spending data, re-scaled to per capita annual spending. Quantities are only partially available, thus we do not use those here. We weight the observations with the sampling weights provided with the data by the Hungarian Central Statistical Office.

Due to data limitations, we cannot exactly separate those consumption categories which are affected by the unhealthy food tax and those that are not. Therefore, based on the six-digit COICOP (classification of individual consumption by purpose) codes, we focus on three groups of food spending. The first group, which is the treatment group, consists of sugary food (including chocolate, candies, desserts, and ice cream). This is the group which we can most reliably identify as taxable products. The other two groups of food spending serve as alternative comparison (control) groups. The first control group is the group of pasta products and couscous ("pasta products", henceforth). This group was selected because out of 13 categories of processed food, before the introduction of the tax, the time pattern of expenditure on pasta products was the most similar to the time pattern of expenditure on sugary food. Thus, without the tax policy, expenditure on pasta products and expenditure on sugary food

[2] The formula of the inverse hyperbolic sine function is: $\text{asinh}(x) = \ln(x+(1+x^2)^{0.5})$, which, unlike the logarithmic transformation, is defined also for zero values. Bellemare and Wichman (2020) derive the properties of the *asinh* function. The coefficient estimates under the *asinh* transformation can be interpreted the same way as under the logarithmic transformation.

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TABLE 1 Firm level descriptive statistics (years 2008–2016)

	Sweet food producer		Other food producer	
	Mean	S.E. of mean	Mean	S.E. of mean
Revenue from inland sales (1000 HUF)	550,745	57,676	940,799	27,995
Revenue from export sales (1000 HUF)	391,625	65,159	437,871	19,741
Volume of inland sales (tons)	553	67	3573	134
Volume of export sales (tons)	514	119	1272	62
Fraction of exporting firms	0.617	0.025	0.261	0.015
Personnel expenditure (1000 HUF)	159,935	16,015	189,533	4930
Number of workers	55	4	65	1
Fraction of size < 50 firms	0.698	0.024	0.668	0.017
Average number of firms	43		932	
Distribution of firms by export activity and size				
	sweet food producer		other food producer	
	size < 50	size ≥ 50	size < 50	size ≥ 50
Not exporter	33.1%	5.0%	54.3%	11.1%
Exporter	36.7%	25.2%	15.7%	18.9%

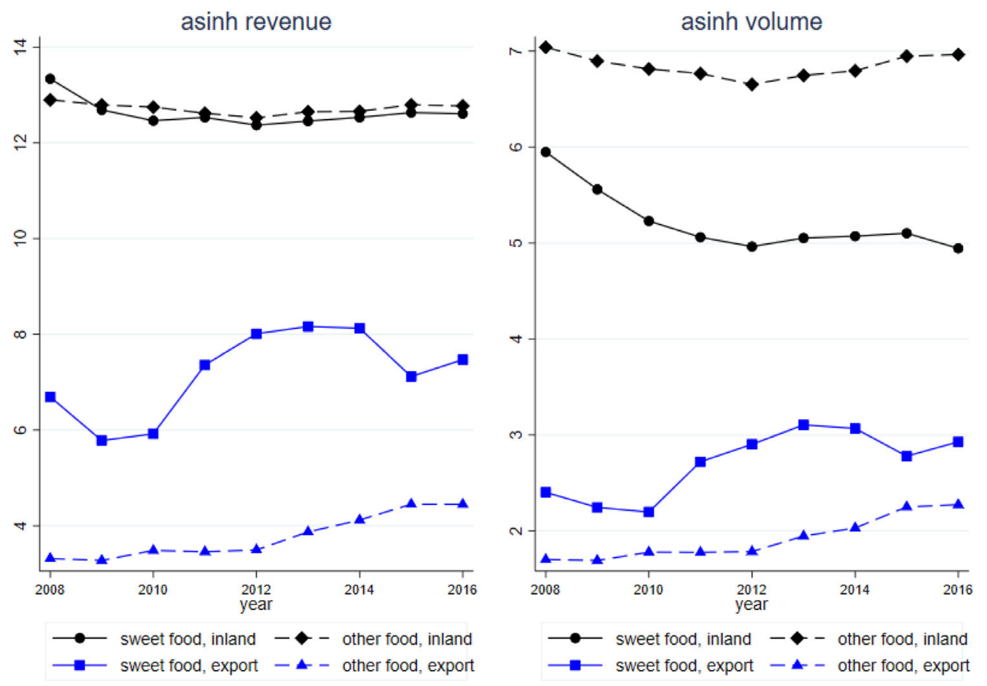

FIGURE 2 Firm level sales revenues and volumes over 2008–2016 [Color figure can be viewed at wileyonlinelibrary.com]

have parallel trends.[3] The second control group consists of jams. Jams are in principle taxed, however, producers could avoid the tax by modifying the contents of the product (see Section 2). Jams serve as a suitable control group because economic circumstances seem to affect their consumption similarly as the consumption of sugary food. A broader category of processed food or other food categories do not appear as suitable controls group in the household level analysis because the common trend assumption does not hold—see Section 4 for details on the estimation method.

[3] We applied the "synth" Stata module (Abadie et al., 2014) to implement the synthetic control method, using spending on a broad list of product categories (13 categories) in years 2008 to 2010 as predictors. The procedure gave a weight of 92% to the food category of pasta products and the rest (8%) to meat products. Because of this result, we proceed with using pasta products as the baseline control group in a standard difference-in-differences framework.

TABLE 2 Household level descriptive statistics (HBLCS data, years 2008–2014)

	Mean	S.E. of mean
Per capita annual spending (HUF)		
Sugary food	6249	32.42
Pasta products	3416	16.78
Jam	470	4.80
Household characteristics		
Age of household head	53.45	0.066
Education level of household head		
Primary	0.22	0.002
Lower secondary	0.36	0.002
Upper secondary	0.27	0.002
Tertiary	0.15	0.001
Household size	2.47	0.006
Can afford holiday	0.36	0.002
Lives in the capital	0.20	0.002
Average number of households	8501	

We construct per capita measures of annual spending by dividing the household level spending by household size. We deflate the spending values to year 2008, and winsorize all outcome variables at 95% due to the noisiness of the survey data.

Table 2 shows that on average (using data from 2008–2014), per capita annual spending on sugary food is twice as much as on pasta products and is about twelve times as much as the spending on jam.

We use the following household level indicators as control variables in the regressions: age and aged squared of the head of the household, education level of the head of the household (primary, lower secondary, upper secondary, tertiary), household size, the quintile of the household level per capita net income (calculated by the Hungarian Central Statistical Office), the binary indicator if the household can afford to go on a holiday at least once a year, and the binary indicator if the household lives in the capital city (Budapest).

4 | METHODS

To analyze the impact of the unhealthy food tax on firms, we estimate the following model:

$$y_{it} = \alpha_0 + T_t\alpha_1 + D_iT_t\beta_t + \eta_i + \varepsilon_{it}, \qquad (1)$$

where y_{it} is one of the outcome variables of firm i in year t. The dummy variable D_i equals 1 if firm i is a sugary food producer throughout our observation period, zero for all the other food producers. Vector T_t consists of year dummies. β_t are the coefficients of main interest, capturing time-varying treatment effects. Lastly, η_i captures firm fixed effects (such as firm location or ownership structure), and ε_{it} is the error term. We cluster the standard errors at the firm level. The model relies on the assumption that without the introduction of the unhealthy food tax, the time trends of the outcome variables are similar in the treatment and control groups. The compositional differences presented in Table 1 do not invalidate this empirical approach.

Equation (1) estimates separate treatment effect for each observation year. This specification allows the effect of the sugary tax to vary over time, also, it reveals the credibility of the common trend assumption (before the introduction of the tax). As an alternative specification, we estimate a model where the treatment effect varies only after the introduction of the tax (i.e., after 2011). Finally, we also estimate a standard difference-in-differences model which gives an average treatment effect for years 2011–2016.

To analyze heterogeneities in the treatment effect, we re-estimate Equation (1) on subsamples according to firm size (with a cut-off at 50 workers) and export activities.

We use a model analogous to Equation (1) to analyze the effect of the unhealthy food tax on household level spending. We estimate the following model:

$$c_{hgt} = \gamma_0 + T_t\gamma_1 + D_gT_t\delta_t + X_{ht}\gamma_2 + \varepsilon_{hgt}, \qquad (2)$$

where c_{hgt} is the annual spending of household h on food group g in year t (either in level or *asinh* form). The food group is either sugary products or the control food category (pasta products or jam). We also include year effects (T_t) and allow these to vary by food group, primarily to capture the time-varying effect of the unhealthy food tax on the two food categories, but also to check the credibility of the common trend assumption. The coefficients of main interest are δ_t. Vector X_{ht} includes control variables listed in Section 3.2. Because each household remains in the sample on average for less than 3 years, we include a rich set of household level control variables (which are partly time-invariant), rather than household fixed effects. We cluster the standard errors at the household level.

Similarly to the firm level analysis, we estimate two alternative specifications: first, with time-invariant treatment effects before the introduction of the tax; second, with time-invariant treatment effects both before and after the introduction of the tax.

Finally, we analyze heterogeneities in the treatment effects by quintiles of household income and by living area

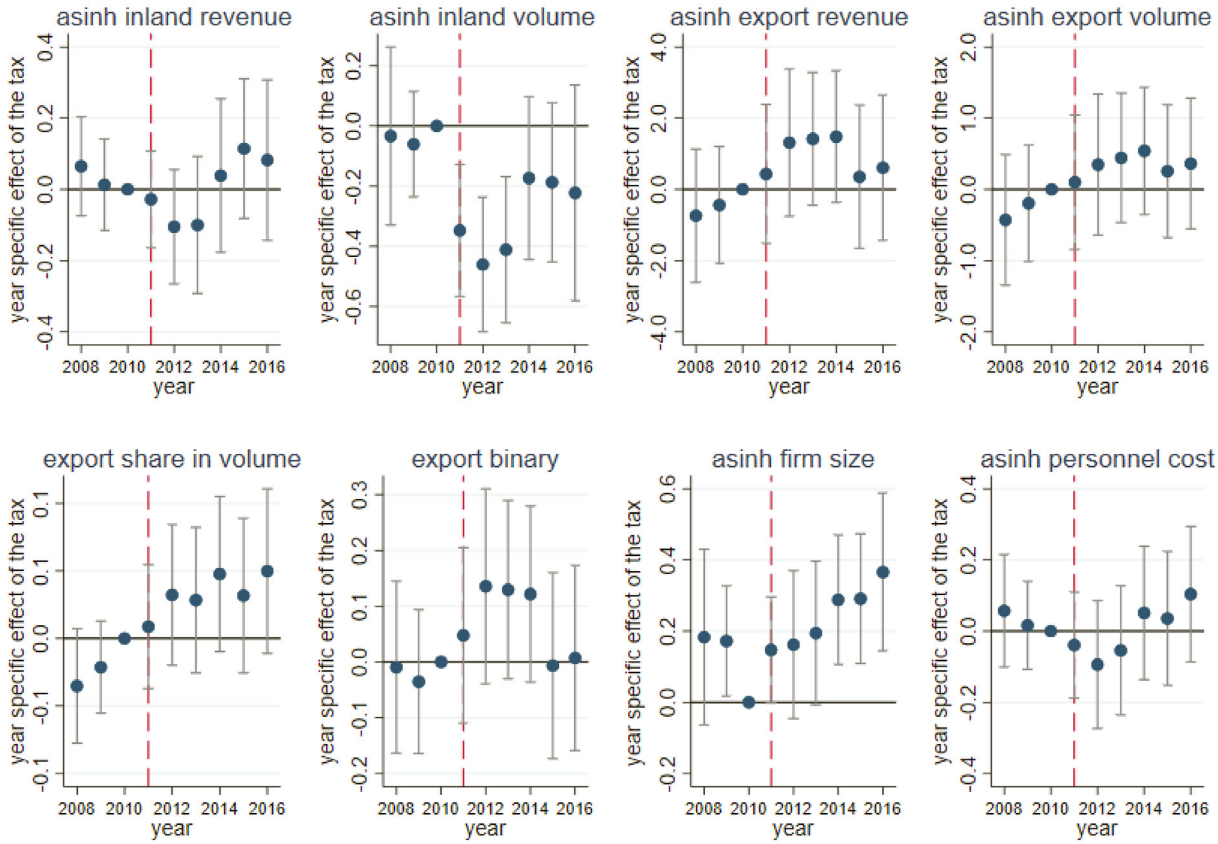

FIGURE 3 Estimated effect of the unhealthy food tax on sweet food producers.
Note: β parameters of Equation (1) are displayed with 95% confidence intervals. 2010 is the baseline year.
[Color figure can be viewed at wileyonlinelibrary.com]

(Budapest or elsewhere). For the sake of brevity, we perform the heterogeneity analyses using pasta products as control group, only.

5 | FIRM SPECIFIC RESULTS

Figure 3 presents the β parameters of Equation (1) (year specific treatment effects using year 2010 as baseline). The common trend assumption seems to hold for all outcomes except for firm size, export revenue, and volume. Although statistically insignificant, the difference in export revenue and volume between the treatment and control groups in year 2008 and 2009 are large, suggesting a diverging trend. This has to be kept in mind when interpreting the estimated effects on export related outcomes. For the other outcomes, the coefficient estimates for years 2008–2009 (i.e., the years before the introduction of the unhealthy food tax, except for 2010, which is the baseline) are statistically insignificant.

We see a relative decline in inland sales revenue and inland sales volume of sweet food producers around years 2011–2013. We attribute these negative tendencies to the unhealthy food tax, partly because of the timing, and partly because no such negative effects can be observed for export revenue and volume, which are not taxed. In years 2011–2013, the magnitude of the negative effect on revenue (around 3% to10%) was smaller (and statistically insignificant) than on volume (around 30% to 37%), suggesting that firms could partly shift the tax burden onto consumers. The calculation of the estimated effects in percentages is based on Equation (12) of Bellemare and Wichman (2020). The results also show that after 2013, the negative impact of the unhealthy food tax on firms' inland sales volume halved and became statistically insignificant, indicating that firms could compensate the tax burden by various strategies, such as changing the product composition (in line with the findings of National Institute for Health Development, 2013) or focusing more on the export market. An alternative explanation is that with the recovery from the crisis, the demand effects of the tax declined, thus the turnover of the sweet food producers could drift back to the pre-tax levels.

The unhealthy food tax had no significant effect on export revenue and export volume, which is reasonable as products sold abroad were not subject to the tax. At the same time, we find weak evidence (significant only at the 10% level) that the tax increased the likelihood of having any exports among the sweet food producers. While we do not see any clear effect on firm size due to the violation of common trend assumption, personnel costs seem to have decreased by around 9% as a consequence of the tax, although these effects are not significant statistically at the 5% level. These results suggest weak evidence that sweet food producers tried to compensate the tax burdens with wage reductions.

The specification checks reported in panel A of Table 3 indicate that if the pre-treatment difference between the treatment and control groups is assumed to be fixed then the estimated treatment effects on inland sales revenue and volume are similar to the baseline results (Figure 3). The results of the standard difference-in-differences specification (panel B) show that on average, over years 2011–2016, the unhealthy food tax decreased the inland sales revenue of sweet food producers by a statistically insignificant 3%, whereas the negative effect on inland sales volume is a significant 26%. Also, we estimate significant positive effects on export revenues and volumes, however, since the common trend assumption is questionable for these outcomes (see Figure 3), these export-related estimates are likely to be upward biased. The likelihood of having any exports is estimated to increase by 14% to 16% among the sweet food producers in years 2012–2014.

The results of the heterogeneity analysis (Figure 4) show that the negative effect of the unhealthy food tax on inland sales volume was stronger on the smaller and exporter sweet food producers. Albeit the differences between small and bigger firms, and exporters and non-exporters are statistically insignificant, those are not negligible in magnitude. Looking at year 2012 and on inland sales volume, the reducing effect of the tax was 24% among bigger firms and 43% among smaller firms; 39% among exporters and 16% among non-exporters (again, using the approximation of Bellemare & Wichman, 2020). The heterogeneities in the effects on the other outcomes are weaker both statistically and quantitatively.

6 | HOUSEHOLD SPECIFIC RESULTS

Figure 5 presents the main results based on the household level HBLCS data (δ parameters of Equation (2)). Based on the parameters referring to the pre-treatment period (years 2008–2009, with 2010 as the reference year), we conclude that the common trend assumption holds. According to our estimates, the unhealthy food tax decreased the household spending on sugary food by around 6% to 12% in year 2011, which reducing effect turns to increasing effect over years 2012–2014. The estimated effect for year 2011 is statistically significant at the 5% level only under the linear specification and only if jam is used as the control group. Note, that any decreasing effect on household level spending is estimated only for year 2011. Considering that the unhealthy food tax was introduced in September, this result suggests that the tax has the strongest impact on demand in the year of its introduction. These estimates are broadly in line with the statistically insignificant effects on the inland revenue of sweet food producers (Figure 3).

The estimated effects on the *asinh* and linear spending outcomes change little if we do not estimate year specific effects for the years before the unhealthy food tax was introduced (panel A of Table 4). Finally, as panel B of Table 4 shows, the average effect of the unhealthy food tax on sugary food spending over years 2011–2014 was about 10% to 50% (using the approximation of Bellemare & Wichman, 2020)—again, a larger effect is estimated if jams are used as the control food category. However, it is unlikely that such large increases in spending were due to the tax itself as we discuss in more details in the next section.

The results of the heterogeneity analyses are reported in Table 5. Panel A shows the heterogeneities in the estimated effects by income quintiles. Compared to pasta products, the reductions in spending on sugary food are the highest among the low-income households. At the same time, we also see evidence for temporary reductions in spending in the top income quintile, although only in year 2011. The heterogeneity by living area is even more striking. Decreasing spending on sugary food due to the tax is observed only outside the capital city. As the per capita income in Budapest was 38% above the country average (Hungarian Central Statistical Office, 2020), these heterogeneities likely reflect income differences in the effect of the tax.

7 | DISCUSSION

We analyzed how the unhealthy food tax of Hungary (introduced in 2011) impacted on the revenue, sales volume, personnel costs, size, and export activities of sweet food producers, and compared these effects to the estimated effects on household spending on sugary food. Using the method of difference-in-differences, we found that the tax of approximately 0.43 USD per 1 kg of sugary food led to about 3% to 10% decrease in the net inland revenues of sweet food producers, and 30% to 37% decrease in their inland sales volume in the first and second years after the introduction of the tax. The substantial and statistically significant negative effects on inland sales volume diminished after about 3 years of the introduction of the tax, most likely due to the recovery of the economy from the crisis (the annual growth of GDP was -1.5% in 2012, +2% in 2013, and +4.2% in 2014).

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TABLE 3 Specification checks for the effect of the unhealthy food tax on firm level outcomes of sweet food producers (years 2008–2016)

	asinh Inland revenue	asinh export revenue	asinh inland volume	asinh export volume	export share in volume	export binary	asinh personnel cost	asinh firm size
A: Baseline: 2008–2010								
Sweet producer × 2011	−0.0467	0.742	−0.320***	0.260	0.0237*	0.0616	−0.0578	0.0479
	(0.0427)	(0.551)	(0.117)	(0.245)	(0.0131)	(0.0495)	(0.0434)	(0.0673)
Sweet producer × 2012	−0.125*	1.636**	−0.432***	0.516*	0.0480**	0.150**	−0.114	0.0601
	(0.0714)	(0.690)	(0.129)	(0.307)	(0.0216)	(0.0660)	(0.0822)	(0.106)
Sweet producer × 2013	−0.120	1.744***	−0.383***	0.611**	0.0443*	0.144**	−0.0731	0.0924
	(0.0891)	(0.623)	(0.141)	(0.295)	(0.0260)	(0.0598)	(0.0803)	(0.104)
Sweet producer × 2014	0.0187	1.807***	−0.145	0.709***	0.0636**	0.136**	0.0319	0.186*
	(0.102)	(0.591)	(0.152)	(0.272)	(0.0272)	(0.0574)	(0.0875)	(0.103)
Sweet producer × 2015	0.0947	0.679	−0.159	0.423	0.0476*	0.00784	0.0165	0.188*
	(0.0952)	(0.639)	(0.149)	(0.285)	(0.0263)	(0.0570)	(0.0916)	(0.107)
Sweet producer × 2016	0.0620	0.935	−0.194	0.531*	0.0659**	0.0214	0.0844	0.264**
	(0.114)	(0.649)	(0.207)	(0.276)	(0.0260)	(0.0568)	(0.0915)	(0.130)
B: Composite treatment effect								
Sweet producer × (2011-2016)	−0.0314	1.256**	−0.289**	0.491**	0.0464***	0.0912**	−0.0310	0.125
	(0.0634)	(0.515)	(0.125)	(0.237)	(0.0157)	(0.0462)	(0.0655)	(0.0884)
All specifications								
Firm fixed effects	yes	yes	yes	yes	Yes	yes	yes	yes
Year effects	yes	yes	yes	yes	Yes	yes	yes	yes
Number of observations	8808	8808	8808	8808	8575	8808	7519	7555
Number of firms	1859	1859	1859	1859	1794	1859	1597	1602

Cluster-robust standard errors in parentheses.

*** $p < .01$.

** $p < .05$.

* $p < .1$.

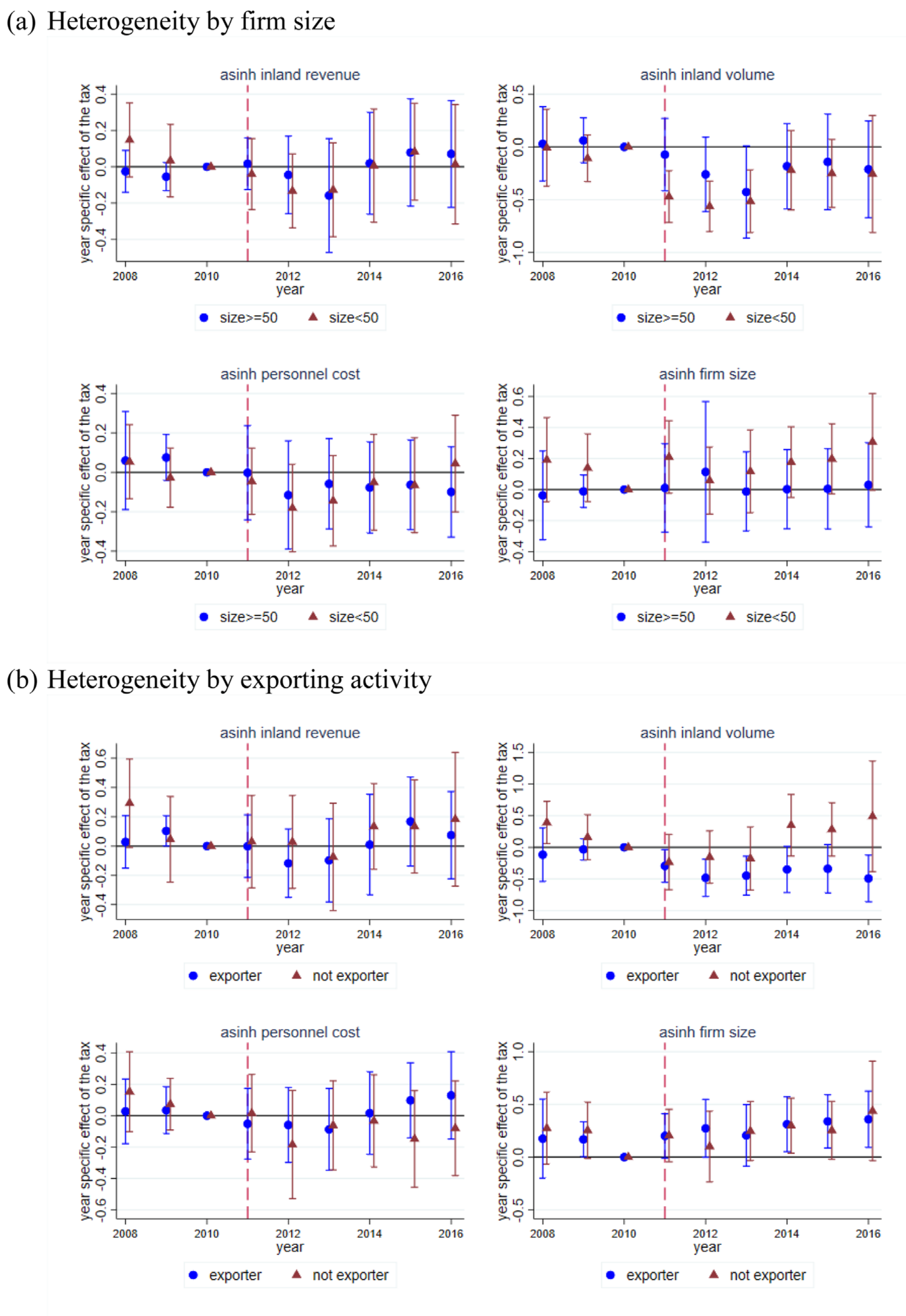

FIGURE 4 Heterogeneity results for the effect of the unhealthy food tax on sweet food producers. (a) Heterogeneity by firm size. (b) Heterogeneity by exporting activity.
Note: β parameters of Equation (1) are displayed with 95% confidence intervals. 2010 is the baseline year
[Color figure can be viewed at wileyonlinelibrary.com]

The reductions in inland sales volume were larger among smaller firms and exporters. There are multiple possible underlying mechanisms. First, the demand for the products of larger firms might be less price elastic (Aalto-Setälä, 2002; Cotterill, 1986; Lamm, 1981), thus such firms might shift the burden of the tax on consumers easier, without substantial decrease in demand. Second, changing the product composition or selling more products abroad so as to reduce the burden of the tax, might be easier for larger and exporter firms. Also, selling more products abroad likely implies that the firm reduces the volume of products sold in the domestic market.

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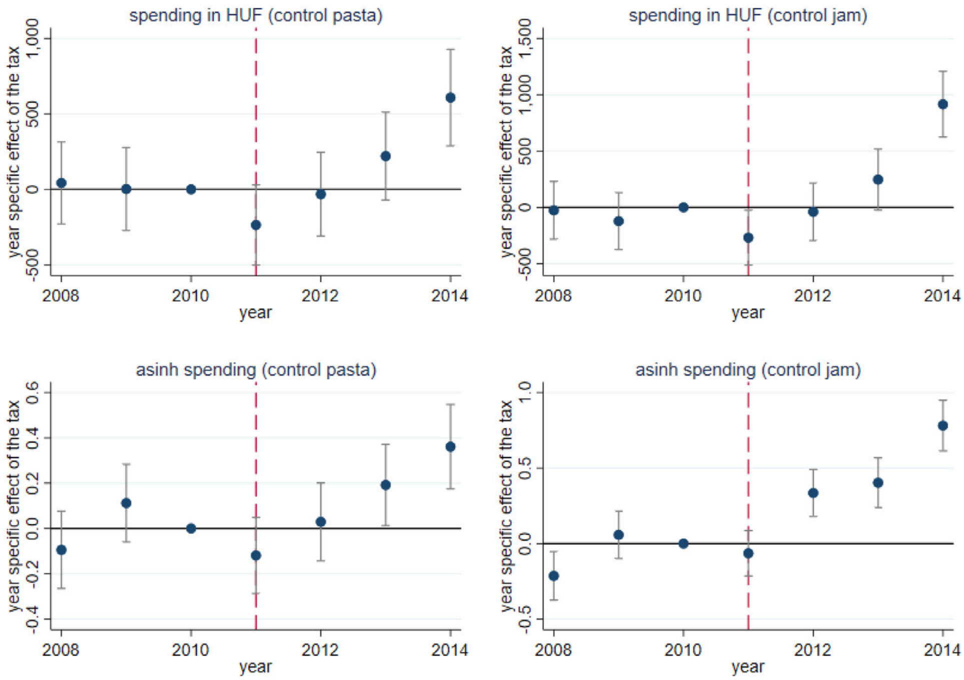

FIGURE 5 Difference between household level spending on sugary food and pasta products or jam.
Note: δ parameters of Equation (2) are displayed with 95% confidence intervals. 2010 is the baseline year
[Color figure can be viewed at wileyonlinelibrary.com]

TABLE 4 Specification checks for the effect of the unhealthy food tax on household level spending on sugary food (HBLCS data, years 2008–2014)

	control: pasta products		control: jam	
A: Baseline: 2008–2010	**asinh spending**	**spending in HUF**	**asinh spending**	**spending in HUF**
Sugary food	0.428***	2760***	5.262***	5626***
	(0.0382)	(61.14)	(0.0353)	(56.99)
Sugary food × 2011	−0.124*	−251.0**	−0.0128	−220.3**
	(0.0720)	(111.4)	(0.0647)	(101.9)
Sugary food × 2012	0.0236	−46.84	0.387***	8.675
	(0.0746)	(119.0)	(0.0678)	(109.3)
Sugary food × 2013	0.187**	205.6	0.455***	295.0**
	(0.0789)	(127.2)	(0.0734)	(118.9)
Sugary food × 2014	0.356***	1132***	0.833***	964.5***
	(0.0829)	(143.9)	(0.0749)	(130.9)
B: Composite treatment effect				
Sugary food	0.428***	2760***	5.262***	5626***
	(0.0382)	(61.14)	(0.0353)	(56.99)
Sugary food × (2011-2014)	0.111**	126.5	0.417***	263.7***
	(0.0550)	(90.65)	(0.0499)	(84.45)
All specifications				
Household level controls	yes	yes	yes	yes
Year effects	yes	yes	yes	yes
Observations	118,928	118,928	118,928	118,928

Cluster-robust standard errors in parentheses.
***$p < .01$.
**$p < .05$.
*$p < .1$.

TABLE 5 Heterogeneity results for the effect of the unhealthy food tax on household level spending on sugary food, using pasta products as control category (years 2008–2014)

A: Heterogeneity by income quintile

	asinh spending					spending in HUF				
	quintile 1	quintile 2	quintile 3	quintile 4	quintile 5	quintile 1	quintile 2	quintile 3	quintile 4	quintile 5
Sugary food	−0.428***	−0.0341	0.0554	0.489***	1.379***	819.8***	1416***	1866***	2745***	5271***
	(0.0871)	(0.0854)	(0.0825)	(0.0770)	(0.0778)	(94.27)	(101.7)	(112.5)	(122.0)	(154.1)
Sugary food × 2011	−0.427**	−0.119	−0.00406	0.195	−0.307**	−294.1	−451.0**	−120.4	217.1	−501.3*
	(0.185)	(0.162)	(0.154)	(0.149)	(0.148)	(208.0)	(190.1)	(214.8)	(236.1)	(274.9)
Sugary food × 2012	−0.321*	−0.309*	0.00361	0.338**	0.137	−516.2***	−343.6*	−135.5	291.2	150.0
	(0.193)	(0.176)	(0.165)	(0.144)	(0.153)	(174.8)	(195.2)	(225.3)	(245.4)	(302.7)
Sugary food × 2013	−0.182	0.182	0.209	0.145	0.373**	−293.9	254.2	−1.637	210.2	523.9
	(0.216)	(0.186)	(0.173)	(0.148)	(0.161)	(212.6)	(217.0)	(230.9)	(248.1)	(327.2)
Sugary food × 2014	0.198	0.343*	0.537***	0.323*	0.371**	112.4	380.5	874.3***	745.9**	705.5*
	(0.208)	(0.194)	(0.165)	(0.169)	(0.178)	(212.2)	(261.7)	(259.3)	(310.7)	(365.8)
Observations	17,126	20,108	24,364	27,630	29,700	17,126	20,108	24,364	27,630	29,700

B: Heterogeneity by living area

	asinh spending		spending in HUF	
	not Budapest	Budapest	not Budapest	Budapest
Sugary food	0.235***	1.224***	2357***	4418***
	(0.0421)	(0.0886)	(65.07)	(159.3)
Sugary food × 2011	−0.196**	0.161	−338.5***	90.04
	(0.0785)	(0.173)	(114.9)	(311.8)
Sugary food × 2012	−0.0828	0.449**	−229.3*	679.4**
	(0.0812)	(0.180)	(121.0)	(342.1)
Sugary food × 2013	0.0512	0.724***	111.7	560.6*
	(0.0867)	(0.185)	(134.5)	(337.2)
Sugary food × 2014	0.359***	0.350*	788.8***	−207.9
	(0.0900)	(0.204)	(150.7)	(396.0)
Observations	98,882	20,046	98,882	20,046

Cluster-robust standard errors in parentheses.
$^{***}p < .01$.
$^{**}p < .05$.
$^{*}p < .1$.
Household level controls and year effects are included in all regressions.

Although due to the different methodology and differences in the data used, the results are not directly comparable to earlier findings (Bíró, 2015; National Institute for Health Development, 2013; World Health Organization, 2015), our results reinforce the earlier results on the short run reducing effects of the Hungarian unhealthy food tax on the revenue of affected firms and consumption of the taxed goods. The large short run estimated effects on inland sales volume are in line with National Institute for Health Development (2013), who document based on survey data that the sales of firms producing taxable goods fell on average by 27% in the first year after the introduction of the tax. Albeit we estimate moderate reductions in the spending on sugary food, the (temporarily) reduced consumption of the taxed food is generally in line with findings in the international literature (Redondo et al., 2018; Teng et al., 2019).

We contribute to the broader international literature with analyzing the impact of unhealthy food tax on producers, finding strong negative effects on inland sales volume in the short run. The unhealthy food tax was introduced in an inflationary environment—the annual price index of food in year 2011 was 6.6% (Hungarian Central Statistical Office, 2019). Based on aggregate statistics, we cannot

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figure out the pricing strategies of the firms the tax was levied on. Nevertheless, the result that the negative impact of the tax was stronger on sales volume than revenue suggests at least partial pass-through of the tax to retail prices and strong price elasticity of demand, at least during a recession. This confirms the survey results of National Institute for Health Development (2013): 86% of the producers in their analysis reported full pass-through of the tax to prices. Ecorys, Euromonitor, IDEA and DTI (2014) also report a high pass-through rate of the unhealthy food tax to sweet food prices in Hungary. Our indirect evidence for the pass-through is also in line with earlier findings in the international literature (Berardi et al., 2016; Capacci et al., 2019; Falbe et al., 2015; Grogger, 2017; Silver et al., 2017). We find little effect on personnel expenditure and firm size.

The estimated effects on inland sales revenue and volume are broadly in line with the estimated effects of the tax on household spending on sugary food, as we find only weak evidence that household spending on the taxed food declined. Although we cannot estimate the price elasticity of demand for sweet food, the results do not contradict the international evidence that the demand for sweets decreases with higher prices (elasticity < 1) and low-income populations may be more sensitive to price changes (Andreyeva et al., 2010; Cornelsen et al., 2015; Green et al., 2013).

Our results suggest that unhealthy food tax can reduce the inland consumption of the taxed goods, at the same time, it negatively affects the producers of unhealthy food, as sales revenue and volume decrease. We also see some evidence that firms offset these effects with increasing sales volumes in the export markets. These negative effects on producers imply that producers are likely to lobby against the introduction of such taxes. Also, policymakers have to take into account the economic costs of such negative effects on producers (such as lower income from profit tax, or the consequences of reduced payments to workers). However, our results also indicate that such negative effects on the firms disappeared in Hungary in the middle run, around the recovery of the Hungarian economy from the crisis. This implies that the economic consequences and health-improving effects of an unhealthy food tax strongly depend on the economic climate—during a boom the consumers are less likely to give up the consumption of the taxed ("unhealthy") goods and thus the firms are less affected by the tax. If the price elasticity of the taxed goods decreases with income then that can also explain the observed results.

Our analysis is subject to a set of limitations. We do not have firm level observations on prices, thus we cannot investigate how the pricing strategies of firms responded to the introduction of the unhealthy food tax. We also do not observe such details of the product composition as the sugar content of the goods produced, which would be necessary to investigate the health impacts of the tax. Also, we only have a noisy categorization of firms and products affected by the unhealthy food tax: firms in the treatment group could produce untaxed products, as well, and firms in the control group could produce some taxed products. This measurement error implies that the firm level estimates on inland sales revenue and volume might be downward biased. The causal interpretation of the estimated effects on export revenue is also restricted by the lack of a suitable control group. Finally, we have only annual but not monthly data, thus our estimates for year 2011 capture months both before and after the tax came into effect in September 2011, implying that any effect we observe for year 2011 is driven by the last 4 months of the year and possibly by the preceding months when plans of the tax were already known.

Overall, our results suggest strong negative short-run effects of the unhealthy food tax on sweet food producers' inland sales volume but less so on sales revenue, in line with a moderate reducing effect on household spending on sugary food. The analysis of long-run effects and detailed analysis of firms' response to the tax remain to future research. The policy implications of the findings are twofold. First, the taxation of sugary food might not be effective in reducing the consumption of sugary food under economic upturn. Second, countries contemplating the introduction of unhealthy food and drinks taxes have to calculate with the negative impacts of the tax on producers. Specifically, smaller producers are hit stronger by the unhealthy food tax. If small firms are for any reason strategically important (e.g., to create local jobs or better jobs) then policymakers have to be aware of the negative impacts of the tax on smaller firms.

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