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Long-term impact of unhealthy food tax on consumption and the drivers behind: A longitudinal study in Hungary

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ABSTRACT

Several countries have introduced public health product taxes with the objective of reducing the absolute amount of consumption of unhealthy food and tackling obesity. This study aims to estimate the long-term impact of the Hungarian public health product tax introduced in 2011.

To achieve this, a unique consumer purchase dataset was analysed to examine daily fast-moving consumer goods purchases from a representative sample of 2,000 households from 2010 to 2018. The results indicate that the tax has been fully reflected in consumer prices. A decline in consumption was observed initially, consistent with previous experiences in Hungary and other countries. However, over time, the data suggests a recovery and even an increase in line with the growth of disposable income. The proportion of taxed products in total fast-moving consumer goods purchases increased from 5.9 % (95 % CI: 5.7 % to 6.0 %) in 2010 to 7.4 % (95 % CI: 7.3 % to 7.6 %) in 2018. Furthermore, the tax has contributed to increased inequality as low-income households spend a higher proportion of their total expenditure on it.

Although taxes on unhealthy foods have proven effective in the short-term, they may not be adequate for reducing overall consumption in the long-term, particularly as disposable income increases. In conclusion, implementing complex interventions is necessary to achieve sustainable positive changes in dietary habits.

1. Introduction

Malnutrition and obesity constitute leading causes of global health problems [1]. Consequently, the reduction of the absolute amount of unhealthy food consumption in developed countries has received special attention in recent years. In 2016, the World Health Organisation (WHO) recommended that governments introduce a minimum 20 % tax on sugar-sweetened beverages to decrease consumption and improve the overall health of their populations [2]. The WHO report cites Hungary as a successful example due to the introduction of a public health product tax (PHPT) on sugary and salty products at the end of 2011 [3]. The explicit objective of the Hungarian PHPT was to reduce the absolute amount of consumption of unhealthy food and to promote healthier eating habits.

The tax had a favourable short-term impact, resulting in a significant decrease in consumption, primarily due to the price increase caused by the tax [4–6]. The outcomes observed in Hungary are in alignment with those observed in international contexts. Empirical evidence indicates that the implementation of taxes on saturated fat in Denmark [7], energy-dense foods in Mexico [8], sugar-sweetened beverages in the Philippines [9], South Africa [10], and Portugal [11], as well as soda in Philadelphia [12], has led to a decrease in consumption. Meta-analyses [13–15] have also concluded that taxation is effective in reducing the consumption of unhealthy foods and improving diets. Furthermore, studies applying controlled randomized experiments [16] and model simulations [17–22] have concluded that taxes on unhealthy foods provide significant health benefits, reduce healthcare costs, and improve productivity. An Australian study [23] found that implementing taxes

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on unhealthy products and subsidies on fruits and vegetables could result in a net healthcare cost saving of 3.4 billion AUD.

All of these studies analysed a relatively short time frame, occurring one or two years after the introduction of the tax, or applied own- and cross-price elasticities calculated based on short-term changes. Nevertheless, the long-term consequences may differ from the short-term impacts [24], as consumers become accustomed to higher prices and their income typically increases. Consequently, income elasticity and dietary habits also play a role in consumption. Analysing Hungarian consumption patterns from 2010 to 2018 allows for the estimation of the long-term consumption impacts of the country's unhealthy food tax and the evaluation of the sustainability of the intervention recommended by systematic reviews [25,26]. Therefore, this study aims to understand the long-term consumption effects of the Hungarian unhealthy food tax, which can provide valuable insights for other developed countries. The study focused on two aspects of the long-term impact: whether there was an absolute reduction in the consumption of unhealthy foods, and whether the introduction of the tax might have contributed to an increase in social inequality.

2. Materials and methods

Microeconomic theory posits that consumption is determined by three main factors: the price of products, disposable income (financial conditions), and preferences (behavioural conditions) [27]. Furthermore, the food environment, including socio-cultural factors and availability, plays a pivotal role in food consumption [28]. The research framework is depicted in Fig. 1.

The aim of the PHPT was to increase prices and reduce consumption through the price channel. This impact assessment also considers disposable income. It is well established that consumer preferences and the food environment are resistant to change [29–31], and the authors are not aware of any external factors, such as restrictions on advertising or sales, or long-term comprehensive campaigns to improve diets, that could influence these factors. Previous literature did not indicate any such changes [3–6]. Therefore, these factors were not investigated.

2.1. Data source

This study utilised ConsumerScan panel data provided by GfK, a global market research company. The longitudinal dataset tracked the daily purchases of fast-moving consumer goods (FMCG) made by 2000 Hungarian households. This sample is representative of the country's approximately 4 million households in terms of household size, settlement size, region, having a child aged below 14, and the age of the female household head. GfK has considerable experience in this field of data collection. Several companies and academic researchers [32] have relied on this or similar data sources for analogous purposes as those of the present study [7,11,12,33]. The study used a unique combination of data created specifically for this purpose for the years 2010, 2012, 2015, and 2018. The 2010 data serve as a reference year for comparing consumption in the pre- and post-tax periods.

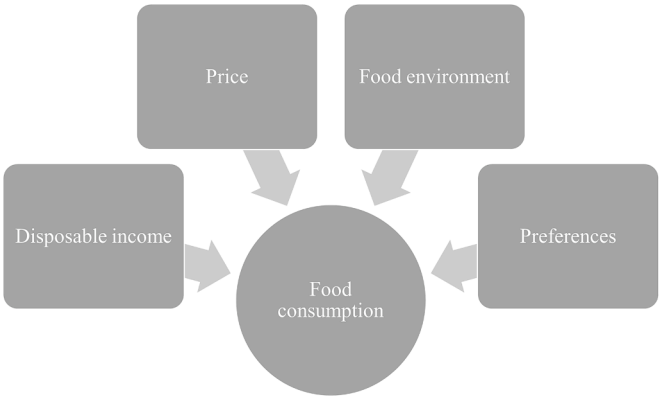

Fig. 1. Research framework.

The dataset includes the total volume and value of PHPT-affected products by product categories, as well as the number of people consuming these products. This allows for analysis of per capita spending and consumption, as well as estimation of the percentage of unhealthy food consumers in the total Hungarian population. The data also covers total FMCG spending and similar products that were not subject to taxation (if available). The dataset is disaggregated by income decile.

The study analysed consumer price index data published by the Hungarian Central Statistical Office (HCSO) to analyse general price trends. Two types of control variables were also used from other sources. Households' disposable income was obtained from the Organisation for Economic Co-operation and Development (OECD). The counterfactual consumption trends of Hungary were approximated by European Union (EU)-level product category-specific consumption trends. For this purpose, the study made use of the sales, export, and import data contained in Eurostat's production of manufactured goods (PRODCOM) dataset.

2.2. Product categories analysed

The Hungarian PHPT was applied to a range of products that are considered to be potentially harmful to consumers' health according to the experts of the Hungarian government:

- Sugar-sweetened (carbonated) soft drinks (hereinafter: sugary carbonated soft drinks)
- Sugar-sweetened fruit drinks with a fruit content below 25 % (hereinafter: low-fruit-content drinks)
- Energy drinks
- Salty snacks, biscuits, and crackers (hereinafter: salty snacks)
- Chocolates (excluding dark chocolates with high cacao content and chocolates made with artificial sweeteners)
- Sweet biscuits and waffles (hereinafter: sweet biscuits)
- Instant cocoa powder
- Alcoholic refreshers (e.g., ciders, cocktails)
- Flavoured beer (both alcoholic and alcohol-free)

The tax was levied on products exceeding a defined threshold of salt or sugar content. The tax rate was determined in nominal terms for each product category based on weight (kg) or volume (l). The relative tax rate varied significantly by product category, ranging from 21 % (for salty snacks) to 2 % (for alcoholic refreshments) of the pre-tax average gross price. For most products, it ranged from 5 to 10 %. The nominal tax values remained unchanged from 2012 to 2018. According to the HCSO, food prices increased by 18 % during this period, resulting in a substantial decrease in the real value of the tax rate.

Pre-tax consumption data shows that chocolates, sweet biscuits, sugary carbonated soft drinks, salty snacks, and low-fruit-content drinks accounted for over 90 % of the total turnover of the taxed products. Due to the considerable weight of these products in the consumption mix, this study will focus solely on these categories.

The study collected data on close substitutes of the five product categories that were not affected by the tax. These substitutes included dark chocolate with high cacao content, sweet biscuits and waffles made with artificial sweeteners, carbonated soft drinks made with artificial sweeteners, and fruit drinks with a fruit content equal to or above 25 %. The purpose was to compare the consumption trends of these substitutes with those of the taxed products [10].

2.3. Estimation methods

The introduction of the PHPT can be viewed as a natural experiment,

similar to changes in alcohol prices and taxes [34]. The identification of an appropriate control group for natural experiments can be a challenging and often impossible task, as the researcher is unable to control the population's exposure to the intervention. However, natural experiments allow for the investigation of large-scale responses to policy interventions [35]. As the PHPT affected the entire Hungarian population, it was not possible to identify a suitable control group. Consequently, the study employs a before-after comparison. This comparison is appropriate as the PHPT aimed to reduce the absolute consumption of unhealthy food as a way to tackle obesity and other negative health outcomes.

The study presents descriptive analyses with confidence interval (CI) calculations to reveal price movements, changes in the percentage of consumers of unhealthy food from the total population, and consumption changes for the aforementioned product categories. Additionally, the study calculates the share of PHPT-affected product categories in total FMCG spending for each year. In all cases, the CIs were calculated based on the standard deviation data provided by GfK. The standard errors for the ratio of random variables were calculated using the delta method [36].

A hypothetical average consumer price was created for each product category to estimate the tax shifting related to PHPT. This was calculated by adding the factors that affect price, namely inflation, value-added tax, and PHPT, to the pre-tax average net prices. The hypothetical average prices assume that all cost and tax changes are perfectly reflected in consumer prices. The comparison between the hypothetical and the observed average prices was used to determine the extent of tax shifting. If the hypothetical price was equal to or lower than the observed price, it indicated that the PHPT had been fully reflected in the consumer prices.

Following the 2008/2009 global financial crisis, there was a substantial increase in both the Hungarian gross domestic product (GDP) and the population's disposable income. The rise in real income may have influenced the weights of various product categories in the total FMCG spending. Consequently, this study aims to examine the changes in the value of unhealthy food consumption and its proportion in total FMCG spending, in light of the real income increase.

Although the study analyses a natural experiment, it seeks to create control groups in two ways to be able to compare changes in consumption of taxed products to a scenario without taxation. Firstly, the study analyses changes in consumption of non-taxed alternative products (if available) using the GfK dataset, which is similar to the approach followed by Bíró [4]. Secondly, the study analyses consumption data from the EU-28 countries (excluding Hungary) using Eurostat PRODCOM. Domestic consumption was calculated as sold production plus imports minus exports. The Eurostat PRODCOM database can be utilised to provide consumption data for the product categories under investigation. However, the database does not differentiate between products based on their sugar or salt content, making it impossible to distinguish between PHPT-affected products and non-taxed alternatives. Consequently, the PRODCOM data is only pertinent to product categories where the majority of items are subject to taxation.

The study analysed inequality by examining the relative burden of PHPT on households across income deciles. To achieve this, the study calculated the proportion of spending on PHPT-affected product categories as a share of total FMCG spending for each income decile.

3. Results

3.1. Prices

The analysis of price shifting revealed that the observed prices were consistently equal to or above the hypothetical prices, indicating that PHPT was immediately and fully reflected in consumer prices. The only exceptions were salty snacks and low-fruit-content drinks, where PHPT was fully reflected in consumer prices only in the medium-term, specifically in 3–4 years (Fig. 2). Although PHPT remained unchanged during the analysed period, the prices of the products exhibited a continuous increase, often matching or exceeding the rate of inflation.

3.2. Disposable income and total FMCG spending

The PHPT was implemented in Hungary in 2011. In 2012, the net disposable income of Hungarian households declined by 3.4 %. During the period from 2010 to 2012, total spending on FMCG increased by 3.7 %, but due to the food inflation rate of 12.9 %, the volume of FMCG goods declined.

After 2012, disposable income in Hungary began to grow, increasing by 8.0 % from 2012 to 2015, and a further 12.5 % increase occurred from 2015 to 2018. Between 2012 and 2015, total FMCG spending increased by 7.1 %, with a food inflation rate of 3.3 %. Between 2015 and 2018, the increase was 9.8 %, with a food inflation rate of 7.9 %.

Overall, during the analysed period, households' net disposable income increased by 21.3 %. Meanwhile, per capita spending on FMCG grew by 22.0 %, with a food inflation rate of 25.8 %. This suggests that, in real terms, FMCG spending decreased slightly, particularly at the beginning of the period under investigation.

3.3. Consumption volume

Between 2010 and 2012, following the introduction of the PHPT, there was a statistically significant decrease in the volume of sweet biscuits, low-fruit-content drinks, and salty snacks purchased (Table 1). However, per capita spending did not change significantly, except for low-fruit-content drinks. Products that were not subject to the tax and that could be considered close substitutes experienced an increase in both value and volume during the same period. The sole exception was high-fruit-content drinks, which demonstrated a significant decline in volume despite not being subject to taxation.

Between 2012 and 2015, there was a partial recovery in the consumption volume of PHPT-affected products (Table 1). The categories of chocolates and sugary carbonated soft drinks already exhibited some volume increase (although it was not significant) compared to 2010, while the other categories did not show any increase. However, compared to 2012, there was an increase in all categories. As a result, the value share of the PHPT-affected product categories in total FMCG increased from 5.9 % (95 % CI: 5.7 % to 6.0 %) in 2010 and 6.0 % (95 % CI: 5.8 % to 6.1 %) in 2012 to 6.7 % (95 % CI: 6.6 % to 6.9 %) in 2015. Although the purchased volume of untaxed products from the same categories also increased between 2012 and 2015, it was lower than the increase of the taxed ones for chocolates and sugary carbonated soft drinks.

Seven years after the introduction of the PHPT, consumption volume significantly increased for all but two product categories compared to the pre-tax level (Table 1). Sweet biscuits and low-fruit-content drinks revealed a volume decline. Per capita spending on PHPT-affected products grew by 54.1 %, indicating that while the real (inflation adjusted) spending on total FMCG declined between 2010 and 2018, the spending on PHPT-affected products increased substantially, at a higher rate than income growth. In 2018, the share of PHPT-affected spending in total FMCG spending increased significantly ($p < 0.001$) to 7.4 % (95 % CI: 7.3 % to 7.6 %) compared to 2010.

The observed increase in consumption volume can be attributed to two main sources: an extensive and an intensive one (Fig. 3). The extensive burden, which refers to the percentage of consumers of unhealthy foods within the total population, significantly increased from 2010 to 2018 for all the product categories analysed, with the exception of low-fruit-content drinks, where there was no significant change. Regarding the intensive burden, which refers to the per capita consumption among consumers, there was an increase in the consumption of salty snacks (0.4 kg/capita; 95 % CI: 0.1 to 0.6) and chocolates (0.3 kg/capita; 95 % CI: 0.1 to 0.5), while there was no significant change in

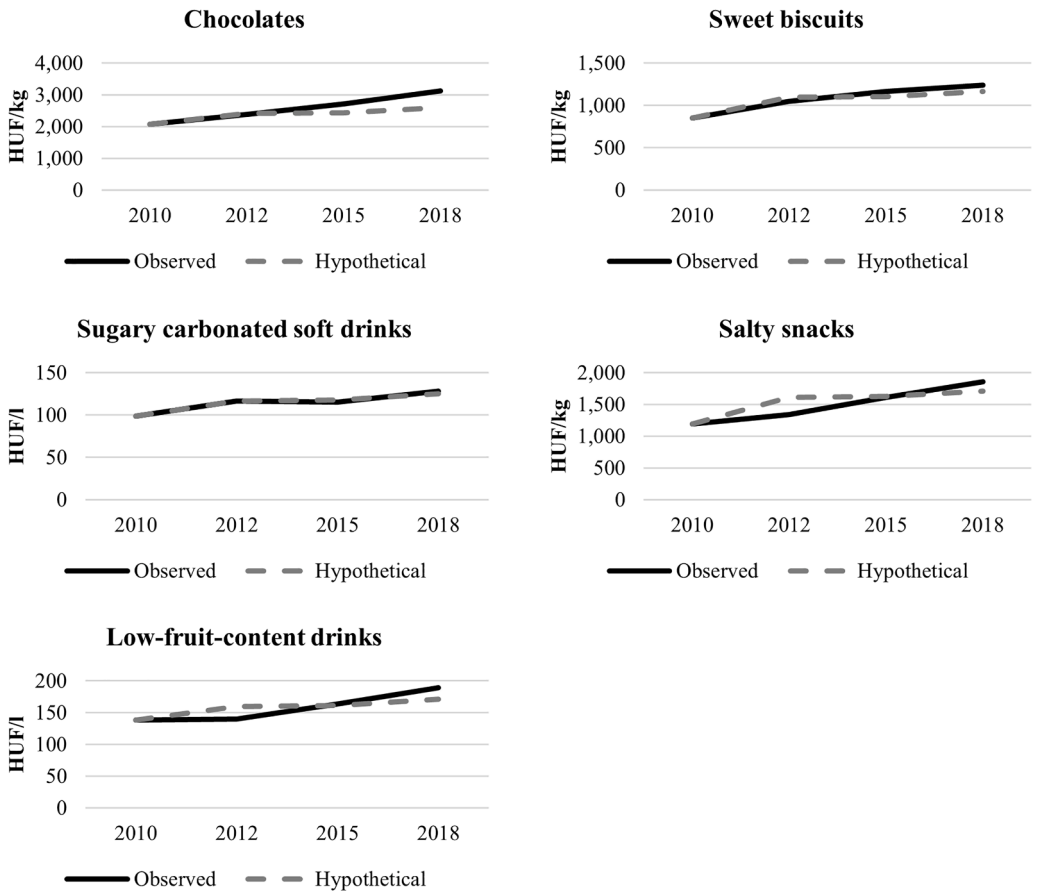

Fig. 2. Observed and hypothetical average prices of PHPT-affected product categories. Hypothetical average prices were calculated by adding inflation, value added tax changes and public health product tax to the 2010 average prices.

Table 1
Volume change of PHPT-affected and similar untaxed product categories.

Product category	Per capita consumption (kg or l)				Change compared to 2010 (kg or l)		
	2010	2012	2015	2018	2012	2015	2018
Chocolates (taxed)	3.1 (3.0 to 3.2)	2.9 (2.8 to 3.1)	3.3 (3.2 to 3.4)	3.5 (3.3 to 3.6)	−0.1 (−0.3 to 0.0)	0.2 (0.0 to 0.4)	0.4 (0.2 to 0.6)
Dark chocolates (not taxed)	0.2 (0.2 to 0.3)	0.3 (0.3 to 0.3)	0.4 (0.4 to 0.4)	0.4 (0.4 to 0.4)	0.1 (0.0 to 0.1)	0.2 (0.1 to 0.2)	0.2 (0.1 to 0.2)
Sweet biscuits (taxed)	3.9 (3.8 to 4.1)	3.4 (3.3 to 3.5)	3.4 (3.3 to 3.5)	3.4 (3.3 to 3.5)	−0.5 (−0.8 to -0.3)	−0.5 (−0.7 to -0.3)	−0.5 (−0.7 to -0.3)
Sweet biscuits with sweeteners (not taxed)	0.1 (0.0 to 0.1)	0.1 (0.1 to 0.1)	0.2 (0.1 to 0.2)	0.2 (0.2 to 0.2)	0.0 (0.0 to 0.0)	0.1 (0.1 to 0.1)	0.1 (0.1 to 0.1)
Sugary carbonated soft drinks (taxed)	28.9 (26.8 to 31.0)	27.0 (25.0 to 29.1)	29.9 (27.9 to 31.8)	32.9 (30.5 to 35.4)	−1.9 (−4.8 to 1.1)	1.0 (−1.9 to 3.9)	4.1 (0.8 to 7.3)
Carbonated soft drinks with sweeteners (not taxed)	6.0 (5.2 to 6.7)	7.3 (6.4 to 8.3)	8.6 (7.0 to 10.2)	10.0 (8.8 to 11.1)	1.4 (0.2 to 2.6)	2.7 (0.9 to 4.4)	4.0 (2.6 to 5.4)
Low-fruit-content drinks (taxed)	11.0 (10.0 to 12.0)	9.2 (8.6 to 9.9)	9.3 (8.5 to 10.1)	8.5 (7.8 to 9.2)	−1.8 (−3.0 to -0.6)	−1.7 (−3.0 to -0.4)	−2.5 (−3.8 to -1.3)
High-fruit-content drinks (not taxed)	10.0 (9.4 to 10.6)	7.1 (6.6 to 7.5)	8.9 (8.4 to 9.4)	12.5 (11.7 to 13.3)	−2.9 (−3.7 to -2.1)	−1.1 (−1.8 to -0.3)	2.5 (1.5 to 3.5)
Salty snacks (taxed)	2.4 (2.2 to 2.5)	2.1 (1.9 to 2.2)	2.3 (2.2 to 2.4)	2.8 (2.6 to 2.9)	−0.3 (−0.5 to -0.1)	−0.1 (−0.2 to -0.1)	0.4 (0.2 to 0.6)

All data are reported as means. The numbers in parenthesis denote 95 % confidence intervals.

the consumption of sugary carbonated soft drinks (2.9 l/capita; 95 % CI: −1.1 to 6.8). There was a decline in the consumption of low-fruit-content drinks (−3.1 l/capita; 95 % CI: −4.8 to −1.3) and sweet biscuits (−0.6 kg/capita; 95 % CI: −0.9 to −0.4).

3.4. EU-level consumption trends

Table 1 demonstrates that for chocolates, sweet biscuits, and salty snacks, there are no non-taxed products or the consumption volume of the non-taxed products is marginal compared to the taxed ones. Consequently, an international comparison can be made for these product categories. It is important to note that most EU countries do not

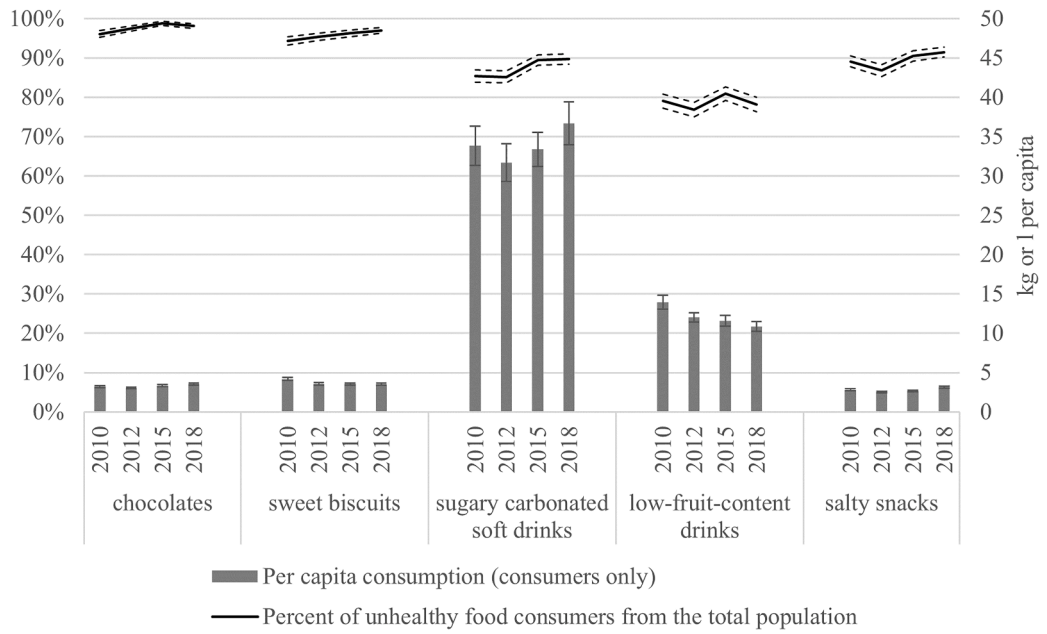

Fig. 3. Percent of junk food consumers from the total population and per consumer consumption of the PHPT-affected product categories. Error bars denote 95 % confidence intervals.

have an unhealthy food tax, so EU-level trends do not reflect the impact of PHPT or similar taxes. A comparison of the changes in consumption in Hungary with the EU average (Table 2) reveals that Hungary experienced a greater increase than the EU average for chocolates and salty snacks. This supports the conclusion that the PHPT was unable to substantially reduce the consumption of unhealthy food in the long-term. The sweet biscuit category may be the only exception, although it is generally a declining category throughout Europe.

3.5. Income inequality

When analysing the Hungarian data by income deciles, it was observed that the consumption of chocolates, sugary carbonated soft drinks, and salty snacks increased for both low- and high-income households. Nevertheless, the increase was not significant for several deciles. Sweet biscuits and low-fruit-content drinks exhibited a general decline in consumption, in line with overall trends (Table 1). Consequently, there was no evidence of divergent trends between low- and high-income households.

The share of PHPT-affected product categories in total FMCG spending also increased across all income deciles (Fig. 4). Although higher-income households spent more on unhealthy products in absolute terms, the share of their spending on such products in total FMCG spending generally decreased as their disposable income increased. For the bottom income decile, the share of PHPT-affected products in their total FMCG spending was significantly higher than for the top income decile in both 2015 ($p < 0.001$) and 2018 ($p = 0.025$).

Table 2
Change in domestic consumption volume between 2010 and 2018 (2010 = 100).

Product category	Hungary	EU-28 (except Hungary)
Chocolates	112	109
Sweet biscuits	87	95
Salty snacks	118	105

Hungarian data is calculated based on Table 1, EU-28 data is calculated from Eurostat PRODCOM.

4. Discussion

This study analysed a nine-year consumer purchase dataset to investigate the long-term effects of an unhealthy food tax on reducing the absolute amount of unhealthy food consumption. The results indicate that the PHPT was immediately and fully reflected in consumer prices, with the exception of salty snacks and low-fruit-content drinks, where this only occurred in the medium-term (i.e., in 3–4 years). This conclusion is supported by other international examples [12,37].

In terms of consumption, there was a notable reduction in the short-term for the taxed products. These results are consistent with previous impact assessments of the Hungarian PHPT [2,4,38,39], which suggest that the tax has reduced the consumption of unhealthy products. Similar taxes in other countries have also demonstrated the same short-term effects [7–12]. However, there was an increase in the consumption of sugary carbonated soft drinks, chocolates, and salty snacks after 2012, with consumption levels significantly surpassing pre-tax levels by 2018. This finding is consistent with the available data on tax revenues, which shows a rise in taxable product sales in Hungary [40]. The increase is primarily due to a growing number of individuals consuming unhealthy food products. However, per consumer consumption either increased or remained the same for the majority of product categories. This indicates that despite the introduction of the tax, consumers continued to consume the same or even higher amounts of unhealthy food as before.

In contrast, there was a decline in the consumption of sweet biscuits and low-fruit-content drinks compared to 2010. The decrease in sweet biscuits was also observed at the EU-level, indicating a general shift in consumer preferences across the continent. In the analysis, low-fruit-content drinks were the only inferior product category. This implies that if consumers have the disposable income to do so, they may switch to high-fruit-content drinks, causing a decline in consumption. As anticipated, the consumption of high-fruit-content drinks increased significantly.

In addition, the consumption of the untaxed alternatives to chocolates and sugary carbonated soft drinks has steadily increased from 2010 to 2018. Consequently, the consumption of taxed and untaxed products diverged in the short-term, indicating that the tax was effective in reducing the consumption of the taxed products in the short-term. However, over the entire period, the increase in volume of untaxed

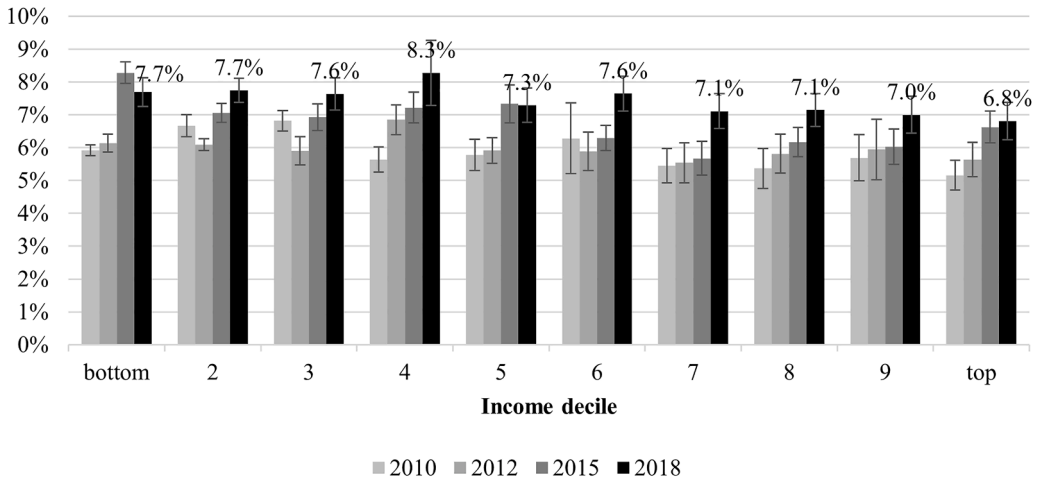

Fig. 4. PHPT-affected product category share in total FMCG spending by income deciles. Error bars denote 95 % confidence intervals.

products was less than the increase in volume of taxed products. This suggests that the tax was insufficient in reducing long-term consumption. It is further supported by EU-level data showing that volume growth for chocolates and salty snacks in Hungary was above the EU average.

Income was one of the primary drivers of consumption growth. While the introduction of the PHPT resulted in some unhealthy products becoming less affordable, it did not alter habitual dietary patterns or restrict availability. Once households had the financial means to purchase the same or greater volume of PHPT-affected products, their consumption returned to the previous levels or increased. Due to the increase in prices, nominal spending has increased, resulting in a greater share of PHPT-affected product categories in total FMCG spending.

The increase in consumption was observed across all income deciles. While high-income households paid a higher absolute amount of this tax, low-income households were nevertheless more adversely affected by it as they spent a higher proportion of their disposable income on it. This is consistent with previous findings that unhealthy food taxes are consistently regressive [41]. Nevertheless, recent studies have presented evidence that challenges this assertion, suggesting that taxes on unhealthy food may confer benefits to low-income groups. However, the results of these studies are not entirely consistent [42]. Given that low-income households are the most vulnerable subpopulation in terms of health, it is recommended that government interventions focus on discouraging them from consuming unhealthy foods. The PHPT was unable to achieve this objective. In fact, seven years after the intervention, consumption increased, thereby exacerbating inequality among households.

The research has limitations that are worth considering. Firstly, it is important to note that the tax shifting analysis only considered average prices. As a consequence of the price increase introduced by the tax, consumers may switch from higher-priced brands to cheaper brands within the same category. This composition effect can cause lower average prices, which creates a downward bias in the actual average prices presented in Fig. 2 [43]. Consequently, the price changes of individual products may be even larger. This implies that the present study's approach is conservative. Secondly, the impact assessment assumes a *ceteris paribus* change that is never observable. Consumption depends, among other things, on preferences, affordability (price and disposable income) and the food environment. In terms of the latter point, these products are widely available and well-known in the Hungarian market, as is the case in other developed countries.

This study presents new evidence on the short- and long-term impact of unhealthy food taxes on consumption. The results show an immediate decline in consumption of the affected product categories. However, this favourable impact diminishes over time, and per capita consumption is higher seven years after the introduction of the tax for most product categories.

It is important to note that the results may have been different in the absence of the substantial growth in disposable income. Nevertheless, a successful programme should be able to deliver results in an environment where GDP and disposable income are growing, as this is the common setting in the majority of countries.

In addition to economic factors, dietary behaviours and the food environment are among the most important factors considered when making a decision about which food to purchase [44,45]. These factors also drive unhealthy food consumption, and they are resistant to change [29–31]. If consumers can afford it, they may choose to allocate a larger proportion of their disposable income to these product categories in order to offset the price increase. It is possible that corporate marketing strategies and the promotion of unhealthy foods may exacerbate this effect, which could be investigated in future research.

Consumption growth could be prevented by increasing tax rates at a faster pace than income growth. However, the price shifting analysis (Fig. 2) indicates that the prices of the taxed products increased in line with or above inflation during the analysed period, despite the PHPT remaining unchanged. The observed increase in consumption occurred under these circumstances. It is crucial to acknowledge that a more ambitious tax and price increase could result in very high tax rates and prices that may not be politically acceptable [46,47]. Moreover, it is important to consider that low-income households may experience a substantial financial burden due to a greater proportion of their disposable income being allocated to these product categories. This can lead to other societal problems. Additionally, there is no conclusive evidence to suggest that higher taxes on unhealthy foods are more effective than lower ones [48].

The implementation of a complex system of interventions is indicated by research as necessary for effective health campaigns [49–54], and that taxes on unhealthy foods alone are not sufficient to tackle unhealthy diets [55]. This is due to the difficulty in altering preferences and behaviours [56,57], particularly among those in the lower-income deciles, where the consequences of unhealthy food taxes are the most pronounced [58]. It is therefore necessary to transform the food environment and break the self-reinforcing feedback loops in order to achieve favourable results [59,60].

Cooperation with manufacturers may be a potential avenue for consideration, but the failure of the Public Health Responsibility Deal in the United Kingdom suggests that industry self-regulation is ineffective [61]. Buse and colleagues have posited that public sector regulation and monitoring are indispensable for the successful implementation of a health programme [62]. Empirical evidence suggests that a whole-system thinking can lead to favourable outcomes [63]. The

integration of psychology, economics, and public health can facilitate the identification of efficacious actions and strategies for the prevention of obesity [64]. The Shape Up Under 5 programme in the US [65] and the Amsterdam Healthy Weight Approach [66] provide illustrative examples of such programmes. Applying these multifaceted interventions will require experts from different disciplines to collaborate. Given the unpredictability of the outcomes of complex interventions, continuous monitoring can provide the necessary information to fine-tune and better target the interventions. This also provides fruitful areas for future academic research. Finally, since public health interventions and prevention programmes have a high return on investment [67], these complex programmes can be profitable to the society in which they are implemented.

5. Conclusions

This study presents the changes in unhealthy food consumption in Hungary following the introduction of the PHPT. As the Hungarian tax on unhealthy foods has been cited by the WHO as a best practice, it is likely that other legislators adopt a similar approach, thereby increasing the relevance of the research. The results indicate that while taxes on unhealthy foods may have a favourable impact on consumption in the short-term, in the long-term, consumption may increase due to the rise in disposable income. The Hungarian experience may also be applicable to other developed countries, as income growth, the food environment, and stable preferences for unhealthy foods are prevalent. In order to offset the effects of income growth, it may be necessary to increase the rate of taxation at a greater pace than the growth in income. However, this is often not a politically viable option. Furthermore, the regressive nature of taxes on unhealthy foods can also contribute to an increase in inequality. This suggests that complex interventions that also target dietary habits (preferences) and the food environment are necessary to achieve sustainable positive changes in reducing both the absolute amount of unhealthy food consumption and inequalities.

CRediT authorship contribution statement

Zombor Berezvai: Supervision, Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Formal analysis, Data curation, Conceptualization. **József Vitrai:** Writing – original draft, Writing – review & editing, Validation, Supervision, Project administration, Funding acquisition, Conceptualization. **Gergely Tóth:** Methodology, Visualization, Writing – review & editing, Validation, Supervision, Project administration, Funding acquisition, Data curation, Conceptualization. **Zoltán Brys:** Writing – original draft, Writing – review & editing. **Márta Bakacs:** Validation, Writing – review & editing, Project administration, Funding acquisition, Conceptualization. **Tamás Joó:** Writing – review & editing.

Declaration of competing interest

Márta Bakacs is affiliated with the National Center for Public Health and Pharmacy that can benefit from up to 10 % of the amount of the public health product tax, which can be used to finance healthcare programs. The other authors declare that they have no competing interests.

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