Sugar tax: the hypothetical case of Sweden

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Abstract

Food is a fundamental part of our life and the relationship we have with it shapes our overall wellbeing. From the social dimensions, to the physical and psychological one, everything depends by our health, and our health is directly linked with what we eat.
The contemporary food environment has been defined as the 'eat more' environment. As a matter of fact, it offers cheap, nutritionally low food while promoting overeating. To improve the overall wellbeing of people it is important to understand why this is the current food environment and how to contrast it. There are different measures implemented at the societal level, by the Governments, to improve the health of people. There are both 'soft' and 'hard' measures. The most implemented 'hard' measures are taxes and regulations that increase the price of foods and push producers to reformulate the nutritionally low, ultra processed food.
One of the most discussed measures is the sugar-tax on sugar-sweetened beverages. This product, particularly detrimental for the health, is terribly consumed. Many Countries have a sugar tax. Sweden, although the high consumption of sugar-sweetened beverages, has never implemented such a measure. Thus, its analysis is fascinating.
In this thesis, I analysed the impact that a hypothetical sugar tax would have on the consumption of SSBs among Swedish consumers. The work was carried out through the study of the scanner data of the ICA Maxi located in Nacka, east of Stockholm. The data was analysed using the Quadratic Almost Ideal Demand System model, through the estimation of the Expenditure, Marshallian and Hicksian elasticities. Different trials with different tax rates have been tested. All the different tax rates show a decline in the consumption of the taxed products. As is it logical, the higher the price increase, the larger the reduction in demand. However, the results of this analysis are modest. As a matter of fact, the 20% tax determines a decrease in the consumption of SSBs by -2.29%, highlighting the need to combine different measures to really change the food consumption patterns of Swedes.

Keywords: Soft drinks, sugar-sweetened beverages, sugar tax, Sweden, marshallian elasticity

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Abbreviations

SSBs	Sugar-sweetened beverages
WHO	World Health Organisation
NCDs	Non-Communicable Diseases
E^m	Marshallian elasticity
E	Expenditure elasticity

1. Introduction

This thesis investigates the relationship between food, environment and people, with a specific focus on the relationship between Swedes and soft drinks.
The contemporary food environment has been defined as the 'eat more' environment. The recent growth of the food production determined a stable and abundant food supply, providing consumers with more food and more calories than ever before.
Our relationship with food has changed in the last 50 years because and as a response to this copious food supply. Food is available everywhere. Both supermarkets and restaurants offer food and beverages in larger sizes compared to the past. These larger sizes of food and beverages are cheaper and more available, consequently causing a higher intake of calories and a higher food waste. The caloric overconsumption is encouraged also by more frequent dining away from home and continuous snacking on high-energy-dense food through the entire day. In the last decades the price of fruit and vegetables has increased while the price of snack and unhealthy food has decreased, contributing to a lower consumption of nutritious food and a higher consumption of nutritionally low food. (Nestle M., 2013).
This food environment has determined in the last decades unhealthy diets, poor eating habits and the current obesity epidemic. Governments are trying to implement different measures to improve the overall health of people. For example, through the implementation of both soft and hard measures such as nutrition campaigns, nudges, taxes and regulations.

One of the most discussed food policies is a tax on sugar-sweetened beverages, the so-called 'sugar tax'. In the scientific literature there are many studies regarding its effectiveness. There are both real world data-based and hypothetical effect assessment studies. One of the most well-known studies is the analysis of the change in consumption before and after the introduction of the sugar tax in Mexico in 2014, carried out by Colchero et al. in 2015. According to this finding, the consumption of sugar-sweetened beverages has decreased, one year after the introduction of the tax, by 6%.

Although there are many studies about real and hypothetical sugar taxes, there are not studies regarding the relationship between Swedes and soft drinks. This thesis tries to address this gap by analysing the impact of a hypothetical sugar tax on SSBs on its consumption among Swedes. I will examine if a sugar tax would decrease the consumption of SSBs among Swedes.

Many countries in North Europe currently have a sugar tax, such as Norway and Finland, while others, like Denmark have implemented similar measures in the past. Sweden is the only country who has never adopted such measure, making it a particularly interesting case of analysis.

The remainder is organised as follows. Section 2 is dedicated to the background: we delve into the causes of the current obesity epidemic and in the role played by sugar. Section 3 contains the materials used and the methodology employed. Section 4 shows the results of the analysis. Section 5 comprehends the discussion and the limitations of the study, while section 6 corresponds to the conclusions.

2. Background

2.1 Globesity: origins and causes of this modern health crisis

In the last decades, obesity and overweight have emerged as public health concern worldwide, affecting millions of individuals. According to the WHO, since 1990 the percentage of overweight adults worldwide has almost doubled, while the percentage of overweight adolescents has quadrupled. Indeed, in 2022, one in every eight people was obese. (WHO, 2025). This phenomenon is known as ‘obesity epidemic’ or ‘globesity’. (WHO, 2025).

Being overweight is socially considered an individual responsibility and it is, sadly, associated with stigma, bullying and isolation. However, this is a multifactorial disease: there are different determinants behind it. There are the individual determinants, such as psychological, genetic and biological factors that interact with the social determinants including economic, cultural and environmental ones. (Bruno et al., 2024.) Social determinants refer to all the factors that are beyond the control of the individual: the type and the composition of the food products that are sold in the supermarkets, the availability of sports facilities, the culture related to food and the type of transport system as well as the type of health care system of the country. (Swinburn et al,. 2011).

The social determinants in which someone grows, and lives can be divided into two opposite categories: obesogenic or leptogenic. An environment is defined as ‘obesogenic’ when it is characterised by “the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations.” (Swinburn et al., 1999)

The western part of the world can be considered obesogenic. As a matter of fact, nowadays we have the highest supply and hence the highest availability of food in history. However, the food production system focuses on high energy dense but nutrient poor food. These products are widely available, affordable and heavily marketed; indeed, this is the only option for the consumers who live in the so-called ‘food deserts.’ On the other side, consumers who do have access to healthy and nutritious food often lack the financial means to buy it or they lack the knowledge to make better food choices. Modern lifestyle has been promoting a more sedentary type of life. In fact, the mechanisation of labour, the motorised

transport system societies rely on and the new ways in which we spend our leisure time have slowly decreased the amount of physical activity we do in our daily lives. (Branca et al., 2007)

The combination of these different factors has gradually modified the relationship between people, food and physical activity, laying the ground of the current obesity epidemic.

2.2 The health and economic costs of globesity

The consequences of the rise of overweight and obesity are not solely the health, social and economic difficulties of the individual but also the externalities imposed on the public health system and on national economy. Thus, this is both a public health and an economic problem. The Government, indeed, can play a crucial role in addressing it.

NCDs consist of a group of chronic diseases that cannot be transmitted from one person to another. These diseases are responsible for 75% of all deaths worldwide. Indeed, WHO estimates that NCDs such as diabetes, lung, heart and cardiovascular diseases caused 43 million deaths in 2021. (WHO, 2024.)
Most of these deaths are preventable if contrasting measure, both at the collective and individual levels, are implemented. (WHO, 2013).

NCDs are determined by a combination of different factors: individual, genetic, behavioural and environmental factors. (WHO, 2024) However, the major causes of NCDs are unhealthy diets, tobacco use, excessive consumption of alcohol and physical inactivity. (WHO, 2013).

The individual burden of these diseases is represented by a lower life expectancy and a lower quality of life. Indeed, due to the long duration, people suffer physically and psychologically for their entire lives. Since overweight is one of the contributing factors of NCDs, it has been estimated that, on average, the OECD countries during the period 2020-2050, will see a reduction of 2.7 years of life expectancy due to it. (OECD, 2019)[1].

[1] This is the average across the entire population and not just for people with overweight.

The burden of NCDs is not solely individual; it is collective too. In fact, the financial cost of obesity and overweight is represented by higher health care expenditure due to the costs of treating an increasing number of patients affected by NCDs and by a lower labour force productivity. (OECD, 2019)

It is estimated that, over the period 2020-2050, OECD countries will spend 8,4% of their health budge treating on treating the consequences of overweight and obesity, while the global economic cost related to NCDs will reach more than US$18 trillion by 2060 if contrasting measures are not implemented. (OECD, 2019; Okunogbe et al., 2022)

The negative impact that overweight has on the labour force productivity, instead, is represented by unemployment, absenteeism, presenteeism and early retirement.

Overweight people who are affected by chronic diseases have a higher probability of not being involved in the workforce. However, when they are involved in it, they tend to take more days off due to the consequences of chronic diseases, and they are more prone to presenteeism: even if they are physically at work, they are less productive. (OECD, 2019)

The consequences that the obesity epidemic has not only on the individual, but on the collective highlight the need to deeply understand its roots and the possible solutions to tackle and address this modern problem.

2.3 The role of sugar

The consumption of sugar provides energy to the human body. However, it doesn’t provide any nutritional benefits; it is classified as a nonessential nutrient. Even if its nutritional value is low, sugar is highly used. It is used as a manufacture ingredient both in people’s daily diet and in the manufacturing of food. In the manufacturing of food it is used to improve the texture of the product, to make it more appealing and to prolong its shelf life. (WHO, 2022.) This massive use of sugar has determined, through time, a rise in its consumption. Indeed, the global sugar consumption is predicted to increase in the decade 2023-2032 by around 1.1% per year and to reach 22.5 kg/per capita in 2032. (OECD/FAO., 2023.)

Sugar is the main caloric sweetener used in the manufacturing of food. As a matter of fact, 80% of the global sweetener utilisation relies on the use of sugar, 8% on high fructose corn syrup (the caloric alternative), while the remaining 12% relies on the low-caloric high-intensive sweeteners such as aspartame and sucralose. (OECD/FAO., 2023.)

Due to the high consumption of sugar and due to its high presence in our food, since 2015 WHO recommends initially reducing the intake of free sugars to less than 10% of total energy intake and further to less than 5% of total energy intake. Who defines free sugars as 'monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook or consume, and sugars naturally present in honey, syrups, fruit juices and fruit juices concentrates.' (WHO, 2015) However, due to the high use of sugar in the manufacturing of food, it is very difficult to decrease the amount one consumes daily.

Products with a high content of sugar should be reduce; indeed, they don't provide any nutritional benefits while increasing the daily calories intake of those who consume them. Sugar-sweetened beverages constitute one of the primary products associated with this category. Empirical evidence indicates that their consumption contributes significantly to long-term weight gain and deteriorating health. (Vertanian et al., 2006).

Given these findings, measures, such as sugar tax, nutritional education in school and reformulation of the processed and ultra-processed food, aimed at decreasing the intake of sugar-rich products, particularly SSBs, should be implemented at both the individual and societal levels.

2.4 The role of SSBs

Sugar-sweetened beverages 'include carbonated and non-carbonated soft drinks, fruit drinks and sports drinks that contain added caloric sweeteners.' (Malik V.S., Hu B.,F., 2019)
Due to the high amount of sugar, SSBs belong to the category of high-energy-dense food. The energy density of a food is the amount of energy per unit of weight. Food with a high energy density provides a significant number of calories per unit of serving, hence it should be consumed in small portions. Food rich in fat or sugar, for example, belongs to this category. (Rolls B.J., 2017.)

SSBs increase the daily energy intake of those who consume it without providing any nutritional benefits while at the same time increasing hunger and decreasing satiety. (Vartanian et al., 2006.) SSBs are linked with positive energy balance: since their consumption is not linked with satiety, when consumed, mechanisms of compensatory reduction in energy intake are not activated. Thus, their consumption has an overall negative impact on weight gain. (DiMeglio D.P., Mattes R.D, 2000.) There is evidence from different studies that one serving per

day of SSBs over a period of one year is associated with an additional weight gain between 0.12 Kg and 0.22 Kg.(Malik et al., 2013)

Despite the negative health effects of SSBs, their consumption has increased in the last decades. From 1990 to 2018, the global consumption of SSBs among adults has increased by 16%, reaching an average global consumption of 248 grams of servings/week in 2018. Evidence shows that every country has experienced a steady increase in its SSBs consumption during the analysed period, except for Latin America/Caribbean and High-Income Countries. The countries with the highest intake are Mexico and the United States, while the countries with the lowest intake are India and China. (Lara-Castor et al., 2023.)

The data about SSBs and its consumption confirms the urge for implementing contrasting measures to improve the relationship between people, the food they eat and their health.

2.5 Measures against the obesity epidemic

The obesity epidemic is a complex problem that requires the combination of different solutions to be tackled and resolved.

Governments can implement both soft and hard measures to tackle this problem. Soft measures appeal to consumers' moral through educational campaigns and nudges, while hard measures, like taxes and laws, usually limit the choices and modify the economic incentives of consumers. (Banerjee S et al., 2021)
Soft measures like food labels and nutritional campaigns are easier and faster to implement, yet they are not the most effective in changing consumers' behaviour. Hard measures like taxes, instead, have a more significant impact. Indeed, they force producers to reformulate their products while effectively changing consumers' food choices.

One of the most discussed and implemented measures, is a tax on sugar-sweetened beverages. In the last decades many countries have implemented taxes not only on SSBs but, broadly, on unhealthy and processed foods. For example, in 2011, Hungary introduced a tax on junk food while in 2011, Denmark introduced a tax on saturated fats. In 2014 Mexico introduced a tax on SSBs, while France and Ireland in 2012 and 2018, respectively.

Some of these taxes have been very effective, showing the potential benefits not only for the individual but for the whole society.

2.6 Objective of the sugar tax

There are different types of taxes according to the outcome that Governments want to obtain. The Economist Pigou was the first one to introduce the idea of using taxes to compensate for the externalities generated by individuals' or firms' behaviour. (Pigou., 1920.)

Externalities are the indirect effects, positive or negative, that the behaviour of an economic agent has on the whole society. Externalities are characterised by a mismatch between the social and private costs and the social and private gains.

Indeed, in the case of negative externalities, the social costs are higher than the private costs. In contrast, in the case of positive externalities the social gains are higher than private.

Negative externalities include pollution generated by production; negative health effects related to the consumption of alcohol, tobacco and unhealthy food.

The sugar tax belongs to the category of taxes aimed at correcting the negative externalities related to an unhealthy lifestyle.

The consumption of SSBs is characterised by two types of externalities: health externalities and fiscal externalities (Allcott et al., 2019). The health externalities are the externalities that impact the single individuals that consume SSBs. They experience a lower quality of life both from a psychological and physical prospective. Indeed, overweight and obese people are more likely to experience discrimination, stigma and prejudice (Foster GD & Kendall PC., 1994, 11: 83-99) as well as malnutrition and micronutrient deficiency. (FAO et al., 2020). The fiscal externalities, instead, are the externalities that impact the whole society. They are represented by the higher financial health-care costs that are borne by society to cover the medical expenses generated by the NCDs caused by unhealthy lifestyles and high daily intake of sugar. (Allcott et al., 2019.)

2.7 The sugar tax around the world

There are many Countries that have introduced a sugar tax; however, the most notable is Mexico's Special Tax on Production and Services implemented in Mexico on January 1, 2014. Mexico has one of the highest consumptions of SSBs worldwide and a high percentage of obesity as well as a high incidence of

diabetes. Thus, the effects of the tax are particularly interesting. This fiscal measure consists of a tax of one peso per litre on drinks with added sugar and an 8% tax on products with a caloric content greater than 275 kilocalories per 100g. One year after the introduction of the tax the consumption of SSBs decreased around 6%, while the consumption of the non-taxed products increased by 4% mainly due to the rise in the purchase of bottled water. (Colchero M.A., 2015).

Many European Countries have introduced taxes either on soft drinks or on processed products rich in salt, sugar and fat. For example, in Hungary in 2011, the Government introduced the 'Public Health Product Tax': a tax on pre-packaged food rich in salt, sugar and caffeine and on sugar-sweetened beverages. Two years after the introduction of the tax, the demand for cola decrease by 10.2%. In France, on the 1st of January 2012, a tax of 7.16€/hl on sugared and non-sugared beverages was introduced. Two years after its introduction the consumption of sugar-sweetened cola decreased by 6.7% while the consumption of artificially-sweetened cola decreased by 6.1%. (European Commission., 2014.)

In the Nordic region, examples of sugar tax date back to the 20th century. Norway introduced a sugar tax in 1920, while Finland in 1940. In 2011, Finland introduced a new legislation regarding the sugar tax, since then it also applies to confectionery and ice cream. Today, the tax on sugar-sweetened beverages consists of 7.5 cents/l. (WHO., 2022) The consumption of SSBs in Finland has been decreasing since 2007, however, from the introduction of the new legislation, the decline has been stronger, as a matter of fact, from 2012 to 2013, there has been a reduction in consumption of 3.8%. (European Commission., 2014.)

Norway introduced the tax to initially increase the revenue of the Government; nevertheless, a new tax in 2009, was introduced and then changed in 2018. In 2018, the Government increased the tax on both sugar and artificially sweetened beverages by 40% reaching 4,75 kroner/l. Evidence shows that the tax decreased the consumption of SSBs by 3.9%. This result, however, is not significant. The authors, indeed, suggest that the tax doesn't increase the price of SSBs enough to have an actual effect on consumption. (Øvrebø et al., 2020)

The case of Norway is a particular example since all the studies regarding the effects of sugar taxes clearly show a decrease in the consumption of the taxed product. However, to have a more accurate analysis, cross-border grocery to Sweden should be included. Sweden doesn't have a sugar tax; thus SSBs are cheaper compared to Norway.

These examples from all around the world show that taxing unhealthy food and especially sugar and artificially sweetened beverages, is a good strategy to change consumers' behaviour. There is, in fact, strong evidence of strategic benefits.

2.8 Swedish consumption of SSBs

Since Sweden doesn't have a sugar tax, it is essential to understand the eating habits and relationship with food of its population to determine if this political measure would have a positive impact on the country's food consumption.

The analysis of food consumption in Sweden between 1960 and 2010 shows that the consumption of minimally processed foods such as fruits, vegetables, eggs and legumes decreased by 2% while the consumption of ultra-processed foods including biscuits, chips and soft drinks (both sugar and artificially sweetened) increased by 142%. Specifically, soft drink consumption rose by 315%.
In 1960, the consumption was 22 litres/capita, while in 2010, 92 litres/capita.

This study analyses the overall Swedish food consumption combined with the trends in overweight and obesity between 1980 and 2010. The percentage of adult obesity rose from 5% in 1980 to 11% in 2010. (Juul & Hemmingsson., 2015.)
Throughout time the percentage didn't decrease, indeed, according to OECD in 2019, the obesity rate reached 15% of the adult population. (OECD., 2023)
The health report made by OECD shows that over 34% of all the deaths in 2019, were caused by behavioural risk factors such as low physical activity, alcohol consumption and dietary risks. In particular, 15% of all deaths were linked with dietary risks. In fact, in 2019 only 8% of the adult population reported eating at least five portions of fruit and vegetables per day, a percentage lower than most European countries. (OECD., 2023)

The type of diet has a fundamental impact on the quality of life. The eating behaviour behind the diet is formed at a very young age and, as all youth habits, is very difficult to change over time. A study on the role of energy-dense but nutritionally low food in the diets of Swedish adolescents during 2017 shows that the consumption of discretionary food such as cakes, biscuits, chips and SSBs contributes to almost 40% of their total energy intake. Particularly, sweets and chocolate contribute to 5.7% of the total energy intake, pies, pizza and sandwiches grant 5.3%, while SSBs provide 3.9%. The consumption of discretionary food is similar among different age groups, and between 51% and 64% of it takes place outside home and school. However, around one third of the energy intake at home and at school comes from discretionary food. (Lindroos et al., 2021.)

The consumption of nutrient food, such as fruit and vegetables, on the contrary, is very low. In 2022, indeed, only 20% of Swedish adolescents reported eating at least one portion of fruit or vegetables each day. (OECD., 2023)

These results clearly show that the Swedish food environment can be considered obesogenic, highlighting the possibility of smaller and bigger changes to help Swedes build a better relationship with food.

3. Data and Methodology

3.1 Data

To evaluate the effect that a hypothetical sugar tax would have on the consumption of sugar and artificially-sweetened beverages in Sweden, I analyse the data regarding the daily purchases of all the beverages sold at the ICA Maxi supermarket located in Nacka, east of Stockholm. The data was collected between 1 August 2020 and 31 March 2021.

The data is organized into 9 categories and into two levels: the upper and the lower levels. The upper level includes all the beverages that are sold in the supermarket. There are 4 categories: beers/ciders, water, juices/must and soft drinks. The lower level, instead, contains all the soft drinks: sugar-sweetened and artificially-sweetened beverages, energy drinks, energy zero drinks, functional drinks and other.

The lower level aggregates to the category 'soft drinks' on the upper level. This two stages division is made to allow consumers to move their money from the lower level to the different categories of drinks in the upper level. This enables consumers to change the budget share for each one of the different categories, so the budget is not constant.

The two different stages enable us to study both how consumers spend their budget between all the different categories and how they spend their budget within the category of soft drinks.

The category "functional drinks" includes all drinks that contain vitamins, electrolytes and minerals. These drinks are meant not only to hydrate but also provide health benefits. The category "other" encompasses all beverages that do not fall under the previously listed classifications, such as smoothies and sweetened fruit juices. The categories containing sugar are sugar-sweetened beverages, energy drinks and other. Therefore, these are the categories subjected to the tax.

The data is organized into categories in order, using the Quadratic Almost Ideal Demand system (QAIDS), to have an accurate idea of how small changes in the prices affect the demand for SSBs in the short run.

The analysis of the data consists of a three steps process: (i) the derivation of the demand for the different categories before the introduction of the tax (ii) the

introduction of the tax on the sugar-sweetened beverages (iii) and the derivation of the new demand after the introduction of the tax.

3.2 Model

The first step in the analysis of the data: the derivation of the demand for the different categories of beverages before the introduction of the tax is carried out using the Quadratic Almost Ideal Demand System model.

This non-linear model enables the estimation of the allocation of the total expenditure of consumers among different goods when the prices and the income change. This model is widely used because it satisfies perfectly the axioms of choice and because, through the restrictions of the parameters, it satisfies the key properties of consumer theory: homogeneity, symmetry and the adding-up property.

Homogeneity implies that, since we look at the relative prices, when all prices and income increase or decrease by the same proportion, the demand of all the goods change proportionally.
Symmetry implies that the substitution effect between two goods is consistent. Thus, it outlines that the effect that a change in the price of good A has on good B is the same that a change in the price of good B has on good A.
Adding up implies that, since we look only at the substitution effect, the income effect is 0, hence the consumer spends entirely their budget.

The model expresses the budget share of each good as a linear function of the logarithm of prices and total expenditure:

$$W_i=\alpha_i+\sum_j\gamma_{ij}\log(p_j)+\beta_i\log(x/p) \qquad (1)$$

The AIDS model allows the estimation of the Marshallian, the Hicksian and the Expenditure elasticity for each one of the categories.

3.3 Estimation of demand before the tax

The first step in estimating the demand before the introduction of the tax is to divide the dataset into two levels: the upper and the lower levels.

This division is made to comprehend how the tax would affect the substitution between the different macro categories of beverages in the upper level, and the substitution within the categories of the sweetened beverages, therefore lower level substitution category was included.
This analysis focuses only on the substitution within the category of the soft drinks, indeed, the substitution in the upper level is not studied. [2]

The AIDS model is estimated using the econometric software TSP. In this model specification, the budget shares w_i are endogenous, thus they are functions of the logarithm of the Price Index (logP) and the logarithm of Income (logX).
The budget share of each sweetened beverage is expressed as follows:

$$W_{i,t} = a_i(1-\rho) + \rho w_{i,t-1} + \beta_i(\log X_t - P - \rho(\log X_{t-1}) - P_{t-1}) + \Sigma \gamma ij\ (\log P_{j,t} - \rho \log P_{j,t-1}) +$$

$$\delta_i/(Q - \rho Q_{t-1}(\log X - P - \rho(\log X_{t-1} - P_{t-1}))^2) \qquad (2)$$

- $W_{i,t}$ is the dependent variable and represents the budget share of good i at time t.
- $a_i(1-\rho)$ is the constant term, adjusted for ρ to capture the effects of past behaviour.
- $\rho w_{i,t-1}$ captures the impact that the share of good i at time t-1 has on the dependent variable. It measures the effect that the previous share of the good i has on the current share of it.
- $\beta_i(\log X_t - P - \rho(\log X_{t-1}) - P_{t-1})$ represents the effect of the real expenditure on the dependent variable. It measures the effect that the real expenditure has on the budget, adjusted for both the current and the lagged income and prices. Indeed, logX is the log of the total expenditure, P is the price index and ρ is the adjustment parameter that captures the past behaviour.
- $\Sigma \gamma ij\ (\log P_{j,t} - \rho \log P_{j,t-1})$ captures the effect that the prices of all other beverages have on the budget share of good i. It reflects both current and lagged effects of the prices. Thus, reflecting that consumers don't adjust their behaviour immediately to price change, but instead, gradually over time.
- $\delta_i/(Q - \rho Q_{t-1}(\log X - P - \rho(\log X_{t-1} - P_{t-1}))^2)$ represents the non-linear expenditure. It reflects the impact of the income on demand when the income itself changes.

[2] However, the upper level has been analysed in order to calculate the Marshallian elasticity of the soft drinks category, which is required for the estimation of the uncompensated Marshallian elasticity.

The dataset contains six categories of beverages; however, the model estimates only five equations, thus it estimates only five budget shares. According to the adding-up property, the sum of all the budget shares is one, hence estimating all the six equations would determine multicollinearity in the model. The equations, indeed, are not independent from one another.
This model estimates the budget share for all the categories of beverages except for the 'other' category. This budget share is calculated afterwards by subtracting the sum of the five estimated budget shares from one. This approach ensures that the adding-up condition is respected while maintaining the model's identifiability. The slopes and the intercepts of the different demand functions are calculated in Excel using the different average prices and quantities and the Marshallian elasticities.

3.4 Introduction of the Sugar tax

Since this is a study on a hypothetical sugar tax in Sweden, the choice of both the type and value of the tax requires some evidence-based data.

Based on real world-evaluations, there is evidence both from the analysis of implemented taxes and from effect assessment studies that the most effective sugar tax is between 10% and 20% of the price of SSBs. Indeed, the introduction of a 10% tax on SSBs is associated with an average decline in both consumption and dietary intake of 10%. (Teng et al., 2019.)

There are many examples from all around the world of 10% sugar taxes. For example, before the introduction of the sugar tax in Ireland in 2018, the Irish Department of Finance requested a Health impact Assessment of the impact on obesity of a 10% tax. The analysis was conducted assuming an own-price elasticity of SSBs of -0,9. The results show an overall decrease in the consumption of SSBs, a reduction in the energy intake by 15 kcal/person/week and a reduction in obesity levels for men by 1.2% whereas for women by 1.3%. (Briggs et al., 2013). On 1 May 2018, the Government introduced two different sugar tax rates according to the sugar content of the SSBs: €0.05 per 330ml can for drinks with a sugar content between 5-8gr per 100 millilitres and €0.24 per 330ml can for drinks with a sugar content higher than 8gr per 100 millilitres, approximately between 10% and 20% of the price of the drinks. Government's evaluation of the tax one year after its introduction shows a decline in the purchase of SSBs in Retail Shops and Food Service about 30,2% and 19,8% respectively. (Houghton et al., 2024)

In 2015, the analysis of a hypothetical sugar tax in the U.S of $0.01/ounce, which corresponds to an increase in the price of SSBs of 16%, showed a decrease in consumption by around 20%. It was estimated that it would reduce obesity among adults by around 0,99% and among youth by around 1,38%. (Long et Al., 2015)

In Mexico the introduction of a 10% tax on drinks with added sugar successfully decrease the consumption of SSBs. Indeed, one year after the introduction of the tax, the consumption of SSBs decreased by around 6%, while the consumption of the non-taxed products increased by 4%. (Colchero M.A., 2015).

Due to the scientific evidence, different trials with a tax between 10% and 20% were conducted to understand the response of Swedish consumers.

3.5 Estimation of the demand after the tax

The effect of the tax is explored through the analysis of the demand of the different categories and through the analysis of the uncompensated price elasticity. This was calculated in Excel for each one of the different categories of the lower level.
For the category sugar, for example, the uncompensated elasticity was calculated as follows:

$$\text{Uncompensated } E^m = E^m_{\text{s-lower}} + (E_s * \text{shares})\,(1+E^m_{\text{s-upper}}) \quad (3)$$

- $E^m_{\text{s-lower}}$ is the Marshallian elasticity of the category sugar of the lower level, calculated by the AIDS model.
- E_s is the Expenditure elasticity of the sugar category of the lower level.
- share_s is the share of sugar in the lower level.
- $E^m_{\text{s-upper}}$ is the Marshallian elasticity of the category of soft drinks of the upper level.

The uncompensated price elasticity allows the evaluation of both the income and the substitution effects, showing how consumers choose to allocate their budget both between the different categories of the upper level and within the categories of the lower level.

The new demands after the introduction of the tax are calculated in Excel through the estimation of the new intercepts.

4. Results

4.1 Descriptive statistics

Table 1. Descriptive statistics of the different categories.

	Min	Max	Mean	Std. Dev
Sugar litres per day	317.6	5202.9	1068.3	679.7
Sugar price (sek)	12.4	23.9	18.9	2.0
Sugar-free litres per day	495.1	3419.7	1240.3	473.4
Sugar-free price (sek)	9.7	17.3	14.5	1.3
Energy litres per day	14.2	106.7	37.1	12.0
Energy price (sek)	34.2	49.7	44.9	2.8
Energy zero litres per day	39.2	207.6	83.8	26.9
Energy zero price (sek)	34.4	50.8	44.9	2.7
Functional litres per day	16.0	108.9	49.7	19.2
Functional price (sek)	47.7	56.5	52.8	1.4
Other litres per day	167.4	612.6	340.1	83.6
Other price (sek)	22.8	33.9	26.9	1.8

Table 1, summarizes the descriptive statistics of the dataset.
On average, the store sold sugar-free beverages the most, at 1,240 litres per day, followed by sugar-sweetened beverages at 1,068 litres per day. The least consumed category is the energy drinks, with only 37 litres per day.
On average, in this store, the most expensive drinks are the functional drinks with a price of almost 53 Swedish krona (SEK). In contrast, the cheapest drinks are the sugar-free ones costing roughly 15 SEK. Energy drinks, whether sugar-sweetened or artificially-sweetened, are also represented by relative high prices. Indeed, both cost around 50 SEK. The sugar-sweetened beverages, instead, are classified within the low to medium price range with a price of almost 19 SEK.

4.2 Elasticities

Table 2. Expenditure Elasticities lower level.

	Sugar	Sugar-free	Energy	Energy zero	Functional	Other
Expenditure	1.30	.943	.644	.533	.532	.588
	(.020)	(.014)	(.047)	(.042)	(.061)	(.029)

According to Engle's law, food demand is income inelastic: as the income increases, the food budget share decreases. Thus, the elasticity for food and beverages is less than one. The expenditure elasticities of the different categories, showed in table 2, vary between 0.5 and 1.3 in conformity with economic theory.

Table 3. Regression results on the demand system: compensated elasticities of the lower level.

	Sugar	Sugar-free	Energy	Energy zero	Functional	Other
Sugar	-.626	.476	.020	.743	.054	.069
	(.082)	(.068)	(.730)	(.014)	(.013)	(.037)
Sugar-free	.382	-.561	.016	.049	.484	.109
	(.055)	(.059)	(.696)	(.014)	(.012)	(.029)
Energy	.508	.509	-1.451	-.015	.591	-.142
	(.188)	(.220)	(.199)	(.216)	(.231)	(.185)
Energy zero	0.823	.679	-.675	-1.222	.502	-.035
	(.164)	(.192)	(.094)	(.211)	(.161)	(.159)
Functional	1.009	.113	.437	.849	-2.983	.576
	(.242)	(.284)	(.171)	(.273)	(.368)	(.237)
Other	.188	.372	-.015	-.867	.084	-.621
	(.101)	(.102)	(.020)	(.393)	(.034)	(.096)

Table 3, shows the compensated elasticities. The compensated elasticity isolates the substitution effect and shows purely the substitution relationship between the different categories. Thus, the consumer maintains the same level of utility before and after the change in the prices.

The own-price elasticities are all negative, the categories sugar, sugar-free and other are inelastic while the categories energy, energy zero and functional are elastic. The cross-price elasticities show both relationships of substitution and complementary. Precisely, the categories sugar and sugar-free are substitutes, while the categories energy and energy zero are complements.

Table 4. Regression results on the demand system: calculated final uncompensated elasticity.

	Sugar	Sugar-free	Energy	Energy zero	Functional	Other
Sugar	-1.209	-0.240	-0.002	-0.044	0.024	-0.138
Sugar-free	-0.041	-1.081	0.000	0.012	-0.017	-0.041
Energy	0.219	0.155	-1.463	-0.041	0.577	-0.245
Energy zero	-0.156	0.386	-0.016	-1.244	0.490	-0.120
Functional	0.770	-0.180	0.428	0.828	-2.996	0.492
Other	-0.075	0.048	-0.026	-0.032	0.071	-0.715

Table 4, shows the uncompensated elasticities. The uncompensated elasticity includes both the income and the substitution effect, indeed, there is no adjustments to income, hence the consumer doesn't maintain the same level of utility before and after the change in the prices. The uncompensated elasticities have been calculated in Excel using the formula (3).

The own-price elasticities are all negative and elastic. Specifically, an increase of 10% in the price of sugar-sweetened beverages will decrease their consumption by 12%, while an increase of 10% in the price of energy drinks will decrease their consumption by 15%. The only exception is the inelastic own-price elasticity of the category 'other'. The own-price elasticity of the functional drinks is particularly: -2.99. This is a very strong effect that can lead to some improbable conclusions about the behaviour of consumers.

The cross-price elasticities between the different categories show both complement and substitute categories. Energy and functional drinks are substitutes of sugar-sweetened beverages. Sugar-free and functional drinks are substitutes for energy drinks, while functional drinks are the only substitutes in the category of other. However, the cross-price elasticity of functional drinks with respect to energy drink zero as well as the cross-price elasticity of functional drinks with respect to the category sugar are very high: 0.828 and 0.77, respectively. This has a strong effect on the results, thus, it can lead to some bias regarding the behaviour patterns of consumers.

4.3 The consumption after the tax

To analyse the effect of the hypothetical tax, different trials with different values of the tax have been tested. Specifically, first a test with a tax of 10%, then with a tax of 15% and finally a test with a tax of 20%. Three of the six categories are the taxable categories: the sugar-sweetened beverages, the energy drinks and the other

one. The tax was implemented on the final price of the different soft drinks containing sugar, hence the sugar content of the taxed products did not change, only their price.

Table 5. Three different scenarios of the change in the consumption of soft drinks.

	Sugar	Sugar-free	Energy	Energy zero	Functional	Other
10% tax	-1.15	0.36	-0.58	-0.09	0.72	-0.52
15% tax	-1.72	0.05	-0.86	-0.13	1.09	-0.78
20% tax	-2.29	0.07	-1.15	-0.18	1.45	-1.04

These results align with the law of demand: when the price of a good increases, its demand decreases. In all three different scenarios, indeed, when the price of the sugar-sweetened products rises due to the tax, their consumption declines.

Among the taxed categories, sugar-sweetened beverages exhibit the largest decline in the consumption following the introduction of the tax.
Parallel to this, the consumption of the artificially-sweetened alternatives increase in all scenarios, the only exception is the energy drink zero. In fact, their consumption diminishes even if this category is not subjected to the tax. This may be due to consumers that are presently more aware of the negative health effects of these products. They may change their consumption patterns towards better choices. Example, they may switch to functional drinks. As shown in table 4, functional drinks are substitutes both of energy drinks and energy drinks zero.

5. Discussion

5.1 Consumption patterns

The aim of this study is to understand a possible response of Swedes to a hypothetical sugar tax on soft drinks.

The results reveal a significantly high consumption of these products among Swedes. As shown in table 1, both the sugar-sweetened and the artificially-sweetened drinks are sold daily in considerable quantities. The sugar-sweetened drinks are sold at 1,240 litres per day, while the artificially-sweetened alternatives are at 1,068 litres per day. The expenditure elasticities and the own-price elasticities are in conformity with both economic theory and with scientific literature. Specifically, the expenditure elasticity of the category sugar is 1.3 while the own-price elasticity is -1.2. For comparison, Colchero et al. (2015) found an income elasticity of 1.06 for soft drinks in Mexico. Similarly, in 2018, the Irish Department of Health, assumed an own-price elasticity of 0.9 for SSBs for its impact assessment. (Briggs et al., 2013).

To comprehend the most effective tax rate, three different tax scenarios have been tested: 10%, 15% and 20% tax on sugar-sweetened beverages. The tax has been applied to the final price of the three categories that contain sugar: sugar, energy drinks and other.
In all three different scenarios, a reduction in the consumption of the taxed products was observed, supporting the law of demand. The higher the price increases, the larger the reduction in demand. The 20% tax scenario, in fact, showed the largest decrease in consumption, by around -2.29%.

From table 5, it is possible to see how, as the consumption of the sugar-sweetened beverages diminish, the consumption of the artificially-sweetened alternatives increases. To have a more complete picture of consumers' behaviour, the cross-price elasticities between the different categories have been calculated. The results show both complements and substitutes. Nevertheless, there is no clear substitution path between the sugar-sweetened products and the artificially-sweetened ones. This may be due to the lack of knowledge of consumers regarding the ingredients and the composition of the different beverages. Certainly, they may categorise all of them as equal beverages without focusing on the lists of ingredients of the different alternatives.

Some of the cross-price elasticities are particularly high compared to the findings in the scientific literature. Specially, the cross-price elasticities of the category functional and other. This suggests a strong degree of substitutability, hence when the price of the SSBs increases consumers shift towards the artificially-sweetened alternatives, instead of decreasing the overall consumption of soft drinks. This substitution pattern may limit the net impact of the tax and explain why the effects of the tax are smaller compared to the other studies in the literature.

Table 5, shows the consumption after the introduction of the tax. The decrease in the consumption of the taxed products is low, it only varies between -1.15 and -2.29. The magnitude of the results is modest compared to the other studies in the literature. Due to the limitations of the study and the type of data or the relatively low level of the tax. The 20% tax rate may not be high enough to determine a substantial change among Swedish consumers. As a matter of fact, the consumption may be so rooted in the culture and in the habits of Swedes that a higher price is insufficient to change their purchasing habits. Additionally, the price after the introduction of the 20% tax may be considered insufficient to change the purchasing behaviours in the short-run. Probably in the long-run, from five to ten years, the 20% tax rate will determine a greater decrease in the purchase of SSBs.

To change consumers' behaviours, there are different measures.
Imposing taxes is the most effective measure. Nonetheless, it is not enough. According to this analysis, for example, to improve the quality of the diets of Swedish consumers imposing, a sugar tax of 20% does not have a great impact on the consumption of soft drinks. Thus, the combination of different measures is necessary. For example, nutrition education in schools as well as clearer and easier nutrition information on the packages of food. Changes to the food environment, such as, the layout of the stores, the disposition of the different products and changes in the servings of the less healthy food; the introduction of stricter rules regarding the marketing and advertising of unhealthy food.

These measures all together provide consumers with the tools to make informed, beneficial and healthy food choices. Giving them the possibility, in the long run, to improve their well-being and overall health.

5.2 Limitations

The results of this study align with both economic theory and the scientific literature. Nevertheless, there are some limitations that need to be acknowledged.

First of all, the study has been conducted using the data collected from only one store. Thus, we don't have conclusions that are generalisable to the broader Swedish population. As a matter of fact, the data we have is representative of a specific segment of the market: the consumers of ICA Maxi located in Nacka, east of Stockholm. Consequently, we have a partial picture of the behaviour of consumers. This introduces some limitations in terms of external validity. For example, we don't know if consumers change stores as the prices change, nor do we have data about how much, generally, they spend in other stores. Additionally, we don't know how the specific characteristics of this ICA, the layout of the store, the promotions, the location, may influence the choices of consumers, nor do we know how broader factors such as cultural norms, economic conditions and individual preferences influence them.

Secondly, to understand consumers' behaviour income elasticity is usually analysed. However, with the available data and due to the characteristics of the AIDS model, it was possible to estimate and use only the expenditure elasticity. While the income elasticity measures how much the quantity demanded of a good change when the income changes, the expenditure elasticity measures how much the quantity demanded of a good change when the total expenditure of the consumer changes. Since the dataset contains data regarding the expenditure and not the income of consumers, and the AIDS model assumes utility maximisation under a budget constraint defined by total expenditure, not total income; the expenditure elasticity was the appropriate and the necessary measure to use.

The expenditure elasticity is a valuable tool to analyse consumers' behaviour, yet there are different possible sources of bias. For instance, the total expenditure variable is influenced by unobserved factors such as savings behaviour, household preferences, time constraints and promotions that can raise the risk of endogeneity bias. Furthermore, using the data only from one store provides us with insights related to the specific retailer environment, rather than to the broader Swedish population.

Regarding the data, it is important to highlight another limitation. The AIDS model is usually applied to household expenditure data, where the entire household budget is observed. Hence, the expenditure elasticity is estimated with respect to the entire household expenditure. In this study, however, the data comes from only one store. Therefore, the expenditure elasticity has to be interpreted as relative to the expenditure within the store, rather than to the total household expenditure. This limits the generalisation of the results since it is unknown

whether, where and in what quantities consumers purchase soft drinks in other stores.
However, the characteristics of the store partially mitigate this concern: it is a big supermarket, it does not face direct competition from other stores in the area, and consumers usually travel there by car to do a larger shopping.
Nevertheless, the consumer-base of this store is represented mainly by middle-income households, which further limits the extent to which the findings can be generalised to the broader Swedish population.

Lastly, the analysis of the impact of taxes on the consumption of different products often indicates problems with autocorrelation. Certainly, the LM test indicates problems with autocorrelation. The p-value of the categories energy drink, energy drink zero, and functional is smaller than 0.05. To fix this, the model was tested with different combinations of lagged variables. The different combinations focused on modifying the lag structure of the variable of total expenditure and price of the categories affected by autocorrelation. Specifically, various lengths were introduced individually and in combination with energy drinks and functional ones to capture delayed consumer response. Despite these trials, the LM continues to indicate autocorrelation.

Since this is a common issue and numerous unsuccessful trials have been carried out to fix it, the analysis has been carried out despite its presence. This limitation should be considered, particularly in relation to the affected categories.

6. Conclusions

The study has tried to analyse the consumption behaviours of Swedes regarding the different beverages that belong to the category of soft drinks. The aim was to understand whether a hypothetical tax on sugar-sweetened beverages would lead to a reduction in their consumption among Swedes.
Three different tax scenarios have been tested, and the results of each one of them are consistent with the fundamental laws of economics, showing how a sugar tax could serve as an economic lever to discourage the consumption of SSBs, aligning with prior studies in other countries. The results are modest, a tax rate of 20% decreases the consumption by about -2.29%, As a matter of fact, to effectively decrease the consumption of unhealthy food, the best strategy consists of combining different measures.

Even if these results align with the expected outcome, this study has some limitations. Due to the lack of external validity, the results of this analysis cannot be extended to the entire Swedish population. Consequently, further research with a dataset covering data from different stores located all around Sweden for a longer period may give a more accurate picture of the relationship between Swedes and soft drinks.

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