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The role of sugar products and non-alcoholic beverages in the food budget: change across birth cohorts and between socio-economic groups

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Abstract

Purpose – This study investigates how the consumption of sugar products and non-alcoholic beverages has changed across birth cohorts. In addition, this study examines how the socio-economic gaps in the consumption of said products have evolved across birth cohorts.

Design/methodology/approach – The research data are drawn from the Finnish household expenditure surveys covering the period 1985–2016 ($n = 44{,}286$). An age-period-cohort methodology is utilised through the age-period-cohort-trended lag model. The model assumes that the linear long-term component of change is caused by generations replacing one-another, and that the age effect is similar across cohorts.

Findings – Sugar products and non-alcoholic beverages occupied a larger portion of more recent birth cohorts' food baskets. Cohort differences were larger in beverage consumption. Lower income was associated with a higher food expenditure share of sugar products in several cohorts. A higher education level was linked to a higher food expenditure share of sugar products in more cohorts than a lower education level. In cohorts born before the 1950s, non-alcoholic beverages occupied a larger portion of the food baskets of the high socio-economic status groups. This gap reversed over time, leading to larger food expenditure shares of non-alcoholic beverages in low socio-economic status groups.

Originality/value – This study assessed how the consumption of sugar products and non-alcoholic beverages has changed across birth cohorts. In addition, this study assessed how socio-economic differences in the consumption of said products have changed. The results highlight that sugar products and non-alcoholic beverages occupy larger portions of more recent birth cohorts' food baskets. The results also highlight a reversal of socioeconomic differences in non-alcoholic beverage consumption.

Keywords Sugar consumption, Beverage consumption, Birth cohort, Socio-economic differences, Diffusion

Paper type Research paper

1. Introduction

1.1 The changing consumption of sugar products

Sweetness is the most universally liked taste quality among humans (Reed and McDaniel, 2006). When food is scarce, the preference for sweetness steers humans to forage nutritious fruits, berries and honey (Rozin and Todd, 2015). Ten thousand years ago, the Neolithic Revolution saw the beginning of the mass cultivation of crops (Weisdorf, 2005). Three hundred years ago, the Industrial Revolution led to the extraction of sugar from these mass-cultivated crops (Yudkin, 1967). Nowadays, sugar is a key ingredient in food production and can be found in various foods, besides the obvious, i.e. sweets, chocolates and sodas.

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These include yoghurts, sweet- or savoury-packaged snacks, baked goods, chicken/fish nuggets and other reconstituted meat products. In the Western world, most dietary sugar comes from "ultra-processed" foods (Steele *et al.*, 2016; Machado *et al.*, 2019), such as candy, beverages, dairy, cake and cookies (Sluik *et al.*, 2016). Some researchers have speculated that refined sugar in processed foods could be the prime driver of rising rates of obesity and type 2 diabetes (Bentley *et al.*, 2018).

Consumption of added sugars, particularly sugar-sweetened beverages (SSBs), has been linked with adverse health outcomes, including type 2 diabetes, dental caries and metabolic syndrome. However, research on the health effects of sugar is inconclusive (Stanhope, 2016). Health authorities have nonetheless set recommendations for the upper limit of sugar intake. The World Health Organization recommends that added sugar intake should be less than 10% of total energy and that additional health benefits are derived if sugar intake can be reduced to less than 5% of total energy (Borges *et al.*, 2017). In addition, various countries are developing and implementing schemes to tax-added sugars to combat the negative health consequences of excess sugar intake (Cabrera Escobar *et al.*, 2013; Nakhimovsky *et al.*, 2016). In general, people in Europe consume more sugar than recommended, and youths' sugar intake is a particular concern among public health and nutrition professionals (Azaïs-Braesco *et al.*, 2017; Williams *et al.*, 2017).

Cohort analysis is a general strategy of data examination, which seeks to uncover patterns and effects of growing older and/or social, cultural or political change (Glenn, 2005). This research examines changing sugar consumption, focussing on long-term changes observed through birth cohorts. Life-course determinants can be conceptualised through age, period and cohort effects. Age effects relate to changes brought on by ageing and cumulative experience. Period effects correspond to social and historical changes. Cohort effects correspond to formative effects of social change at critical ages (see Luo, 2015). A vast body of the literature shows that added sugar consumption increases from childhood to adolescence and early adulthood, after which it decreases steadily (Bowman, 1999; Krebs-Smith, 2001; Kriaučionienė *et al.*, 2008; Ervin and Ogden, 2013; Sluik *et al.*, 2016). A similar age pattern has emerged from studies on SSB consumption (Kvaavik *et al.*, 2005; Popkin, 2010; Han and Powell, 2013; Miller *et al.*, 2013). This age pattern has been observed at different times, which points to a life-cycle explanation. Thus, the modelling strategy used in this study assumes the age effect to be similar across birth cohorts. Indeed, younger age groups are more hedonistic in their consumption decisions than older age groups (Kuoppamäki *et al.*, 2017). Humans and rats alike consume more calories relative to their body weight in adolescence than at any other life stage, displaying an abnormally great desire for food and drink during adolescence (Wilmouth and Spear, 2009). More generally, humans seem to possess the ability to auto-regulate their dietary energy density according to changing circumstances (Martí-Henneberg *et al.*, 1999; Laran and Salerno, 2013).

Given this age pattern in sugar consumption, it is likely that broader changes and trends in sugar consumption occur in younger age groups. This is where the concept of generation or birth cohort becomes relevant. In their seminal works, Mannheim (1952) and Ryder (1965) argued that potential generation or cohort effects form in late adolescence or early adulthood. Considering that in the Western world in general, and Finland in particular, more recent cohorts grew up amidst an abundant variety of sugar products and drinks, it is possible that they are more accustomed to consuming sugar products than older birth cohorts. For example, in the 1990s in the United States, younger cohorts developed a taste for carbonated soft drinks, while older cohorts' preference for coffee persisted (Drescher and Roosen, 2013).

The theoretical basis for cohort effects in sugar and beverage consumption is sound. Thus, the modelling strategy used in this study assumes that the long-term component of change occurs when generations replace each other. Empirical research on this topic is limited, although cohort studies have explored other food categories (e.g. Drescher and

Roosen, 2013; Mori *et al.*, 2016; Lee *et al.*, 2020). In addition, given that there is a robust age effect in sugar consumption and that developed countries' populations are ageing rapidly (Christensen *et al.*, 2009), the presence of a cohort effect would be obscured if trends are modelled without age as a covariate.

Differences between cohorts can be partly explained by the *cohort replacement* mechanism (Elder and George, 2016), which refers to the fact that old birth cohorts are constantly dying as new ones are born. Social change occurs because newer cohorts, who behave differently and have different attitudes, replace the older ones.

The *diffusion* mechanism, on the other hand, focuses on the rate at which new attitudes or behaviours are adopted within birth cohorts. Typically, those with a high socioeconomic status (SES) are early adopters of new/emerging consumption styles (Katz, 1999; Pampel, 2005). Subsequent cohorts adopt the new behaviour in incrementally increasing amounts, and the link between SES and the behaviour in question weakens across birth cohorts. Higher SES groups might then adopt new ways of distinction. For example, being thin has replaced being overweight as a sign of affluence in the modern Western context. Globally, diffusion dynamics can be seen in how SES differences in food consumption shift as countries get wealthier (Drewnowski, 2003). In Asia, developing countries exhibit a positive relationship with body mass index and SES, but in relatively developed countries, the association is negative (Murayama, 2015). Pampel (2005) showed that for smoking, the highest SES group was associated with smoking in older cohorts, while lower SES predicted smoking in younger cohorts, even though the average effect of SES was insignificant. Thus, a reversal of socioeconomic differences has been observed. These results highlight the need to analyse how the link between SES and consumption evolves over time.

Indeed, when refined sugar first became available, it was a scarce luxury good that only the wealthy could afford. However, now that sugar has become nearly universally available, the socioeconomic differences have been inverted. In contemporary Western societies, those with a lower SES tend to consume more sugar than those with a higher SES (Popkin and Drewnowski, 1997; Thompson *et al.*, 2009; Kotakorpi *et al.*, 2011; Lindblom, 2017; de Mestral *et al.*, 2017). This is due to several factors. Sugar products provide energy at a low cost, which is attractive to low-income households (Drewnowski, 2003). Sugar is also a cheap flavour enhancer and preservative for processed foods. In addition, sugar products provide pleasure and comfort (Cheon and Hong, 2017), and it has been demonstrated that exposure to cues of austerity leads to increased consumption of sweets (Laran and Salerno, 2013).

1.2 Previous findings

Sugar consumption has changed significantly in the industrial and post-industrial eras. Over time, sugar intake seems to increase in nations undergoing industrialisation and modernisation, but intake remains stable or decreases in developed countries (Heasman, 1989; Kearney, 2010). An analysis of over 100 countries showed a 72-kcal/d increase in the intake of caloric sweeteners from 1962 to 2000 (Popkin and Nielsen, 2003). Interestingly, using US survey data from 1982 to 1995, Blisard (2001) did not find a cohort effect in the consumption of sugar and sweets. In addition, a Norwegian study did not find a cohort effect in the consumption of soft drinks (Gustavsen and Rickertsen, 2014).

Socioeconomic differences in the consumption of sugary foods and drinks vary across countries and periods. In the United States, in the period 1994–1996, added sugar intake decreased with increasing income and education (Krebs-Smith, 2001). A Finnish study using data from 2002 to 2007 showed that the consumption of sweets was more common among highly educated women in 2002; otherwise, there were no significant differences (Ovaskainen *et al.*, 2013). Another Finnish study showed that low-income groups expended a greater share of their food budget on sugar, but that the differences between low- and high-income groups narrowed over the period 1985–2012 (Lindblom, 2017). The consumption of SSBs has been found to be more common among low-income than high-income respondents in Finland and the United States (Ogden *et al.*, 2011; Han and Powell, 2013; Ovaskainen *et al.*, 2013). However, SSB consumption did not vary by social class in Colombian children and adolescents (Ramírez-Vélez *et al.*, 2015). Thus, socioeconomic differences should be studied over long periods. This is best achieved by analysing changes in birth cohorts.

This study examines the effects of birth cohort on the consumption of sugar products and beverages. In addition, this study examines how the socioeconomic gaps in the consumption of said products have evolved across birth cohorts. To achieve these ends, the Finnish household expenditure surveys (HESs) from 1985 to 2016 and the age-period-cohort-trended lag (APCTLAG) model are used.

1.3 Study context: Finland

According to food balance sheet data, sugar availability increased from the 1950s to the 1970s (Leppälä, 1992; Natural Resources Institute Finland, 2020). After peaking in 1974, sugar availability steadily decreased. The HESs have shown that the amount of actual packed sugar households purchased decreased from 29 kg to 5 kg per capita per year during the period 1966–2016. However, beverage purchases increased from 10 L to 26 L per capita per year during the period 1966–2016 (Aalto, 2018). The share of total food expenditure of sugar products spiked in 1995 (Lindblom, 2017). In addition, according to surveys conducted between 1998 and 2007, candy intake increased from 10 kg to 15 kg per capita per year (Gallup, 2009). Individual surveys have tracked the consumption of sugar products for a briefer period and showed that over the past decade, self-reported intake of sweets and baked goods remained stable (Helldán and Helakorpi, 2015). However, self-reported intake of juices and SSBs declined somewhat during the last decade. The Finnish National Dietary Survey in Adults and Elderly (FinDiet) has shown that the intake of sucrose, a directional indicator of added sugars, decreased slightly over the last two decades (Valsta *et al.*, 2018). In summary, the research literature indicates that sugar intake has declined in Finland and, at most, stayed stable.

Finland has a history of applying a sin tax to sugar products. The taxation of sugar products is based on the idea that consumers lack self-control and are thus inclined to engage in consumption behaviour that might be harmful to their health. Finland imposed an excise duty on sweets and chocolate during the period 1926–1999. However, this tax did not affect domestic sweeteners, such as xylitol, sorbitol and mannitol. The European Commission decided that this was an undue market advantage and discontinued the tax. However, the tax on SSBs remained (Rauhanen, 2013). In 2011, Finland instituted an excise tax on sweets, SSBs and ice cream. The tax did not affect cookies, which motivated manufacturers to categorise candy-like products as cookies (Kosonen and Ropponen, 2012). The tax also excluded other sugar-containing products, such as milkshakes and juices. In 2017, the tax was abandoned because the European Commission deemed that it skewed competition and defied the rules on state aid. The tax was also criticised for its only minimal effect on consumption of the targeted products.

1.4 Hypotheses

We will now formulate our research hypotheses based on the background provided above. If younger cohorts are consuming more sugar than older cohorts, this fact could be obscured in a periodical examination because of the changing population structure. As the population ages, younger age groups (who are more prone to consuming sugar) are less abundant in the cross-sectional samples. The life-course perspective on cohort differentiation in food habits, coupled with population ageing, warrants the hypothesis that sugar products and non-alcoholic beverages occupy a larger portion of the food baskets of more recent birth cohorts than their older counterparts.

H1. The food expenditure share of sugar products and non-alcoholic beverages is larger in more recent birth cohorts compared to earlier ones.

Based on the research literature, we expect low-income households to expend a greater share of their food budget on sugar products and beverages than high-income households (H2a).

H2a. The food expenditure share of sugar products and non-alcoholic beverages is higher in the lowest income quartile than in the highest income quartile.

We also expect less-educated households to expend a greater share of their food budget on sugar products and beverages than highly educated households (H2b).

H2b. The food expenditure share of sugar products and non-alcoholic beverages is higher in primary educated households than in tertiary educated households.

Next, the diffusion mechanism in the adoption of new consumption habits suggests that socio-economic differences diminish over time. Thus, we expect that the differences in sugar and beverage consumption between income and educational categories have narrowed (H3).

H3. The differences between the highest and lowest income and educational groups in the food expenditure shares of sugar products and non-alcoholic beverages have narrowed across birth cohorts.

2. Material and methods

2.1 Data

The data used were the HESs collected by Statistics Finland (2018). The purpose of the HES is to produce information about changes and population group differences in household consumption expenditure. Eight cross-sectional samples representative of the Finnish household population were used, covering the period 1985–2016.

The data on consumption expenditure were gathered via household interviews, phone interviews, shop receipts and consumption diaries. Information about income and education was obtained from administrative registers. Data on the educational level of the reference person and spouse, if applicable, were obtained from Statistics Finland's Register of Completed Education and Degrees. Income data were obtained from total statistics on income distribution, which describe the registered households' annual income. Full coverage of the registers used in the HESs can be found in the user's manual (Statistics Finland, 2018).

Consumption expenditure was measured in euros (€) and reported in annual terms. In the HESs, data on food expenditure were gathered via shop receipts and consumption diaries from a two-week accounting period. The accounting periods were distributed equally throughout the year to account for seasonal variations in consumption patterns. Households may have submitted shop receipts from 2001 onwards, if they contain information about the products bought. Most groceries are apparent in the receipts. However, foodstuffs that households gather, grow or hunt are enquired about in the consumption diaries. These foodstuffs are then included in the food expenditure at producer prices. Food expenditure is divided into nine sub-categories, according to the international COICOP-HBS classification (cereal products, meat, fish, dairy and eggs, fats and oils, fruit and berries, vegetables, sugar products and other foodstuffs).

The sample sizes varied between 3,551 and 8,258 households. One notable feature of the data was that the response rate fell from 70% to 46% during the period 1985–2016 (Statistics Finland, 2018). This is part of a more general trend of falling response rates in questionnaire research (Brick and Williams, 2013). Statistics Finland used reweighing methods to account for the demographic differences in response rates. After reweighing, the cross-sectional samples are representative of the household population.

2.2 Indicators

The shares of total food expenditure (FES) on (1) sugar products and (2) non-alcoholic beverages are used as the dependent variables. These consist only of purchases made in grocery stores. Purchases made in restaurants or cafeterias are excluded because of a lack of precise data. Purchases of alcoholic beverages are also excluded. Compared to absolute monetary expenditure, FESs have the advantage of measuring the proportion of a specific food category relative to the whole food basket (see Erbe Healy, 2014; Lindblom, 2017). The sensitivity of the results was tested by running the analyses with equivalised and inflation-adjusted expenditure on sugar products and non-alcoholic beverages as the dependent variables.

Sugar products include sugars, jams, chocolates, sweets, ice creams and syrups. Non-alcoholic beverages included soft drinks (excluding mineral waters), juices and sports drinks. Mineral waters are omitted because of their typically low sugar content and their function as a healthier alternative to soft drinks (Bilek and Rybakowa, 2015). Our indicators do not capture sugars obtained from food products from a nutritional perspective, but sugar and soft drink consumption in monetary terms. Regardless, this allows us to study the background factors that predict sugar and non-alcoholic beverage consumption.

The variable indicating the highest educational level in the household was divided into four categories: primary level or less, secondary level, lower tertiary level and upper tertiary level. Income quartiles were calculated using disposable annual household income. Before constructing the quartiles, the variable indicating annual disposable income was equalised using the Organisation for Economic Co-operation and Development's modified equivalence scale and adjusted for inflation (Chanfreau and Burchardt, 2008).

2.3 Modelling strategy

Estimating APC effects poses an identification problem (Glenn, 2005). The linear dependency of age (A), period (P) and cohort (C) results in a situation in which the unique effects of each are impossible to empirically or logically disentangle from one another.

The traditional methodology for modelling APC effects has been the use of constrained generalised linear models (Mason *et al.*, 1973). It is argued that estimation of APC effects becomes possible if at least two age groups, two periods or two cohorts are assumed to have identical effects. These identifying constraints break the linear dependency of A, P and C, making an ordinary least squares solution possible. However, this methodology produces meaningful estimates only if the identifying constraints are properly chosen. Accomplishing this task requires prior information, which is seldom available (Yang *et al.*, 2004).

This study uses a new APCTLAG method that allows us to assess change across birth cohorts and compare the gap in the FES of sugar products and non-alcoholic beverages between the highest and lowest income quartile and primary and tertiary educated groups (Chauvel *et al.*, 2017; Bar-Haim *et al.*, 2019). As most APC models do, the APCTLAG method imposes certain constraints to make the model identifiable. The model identification constraints rest on two key assumptions. First, we assume that a possible changing trend is due to cohort replacement rather than periodical changes. The plausibility of cohort replacement as a motor of change is underlined by the finding that health habits, diet included, seem to track from youth to adulthood (Kelder *et al.*, 1994; Kvaavik *et al.*, 2005). Thus, we impose a slope-zero constraint on the period vector. In other words, the model assumes that long-term changes in sugar consumption are driven mainly by generations replacing each other. The period estimates, therefore, depict “bumps” in the general trend. These could result from taxing policies, for example. Next, we assume the age effect to be similar across birth cohorts. This assumption is substantially justifiable according to previous research. As we saw in the introduction, the age pattern in sugar and beverage consumption has been the same in various countries and time points. APCTLAG constrains the linear trend of age as equal to the average within-cohort age effect. No constraint is now needed in the cohort vector. In this model, the cohort coefficients will include the general trend of social change.

$$\begin{cases} y^{apc} = \alpha_a + \pi_p + \gamma_c + \varepsilon_i \\ \begin{cases} \sum \alpha_a = \sum \pi_p = 0 \\ \text{Slope}(\pi_p) = 0 \\ \text{Slope}(\alpha_a) = \dfrac{\sum \left(y_{a+1,p+1,c} - y_{a,p,c}\right)}{(p-1)(a-1)} \\ \min(c) < c < \max(c) \end{cases} \end{cases} \qquad \text{(APCTLAG)}$$

First, we use the APCTLAG model to estimate the FES of sugar products and non-alcoholic beverages across birth cohorts. To estimate the socio-economic differences in these FESs within cohorts, we first calculate the differences in the average FESs between tertiary- and non-tertiary-educated households, and top-earners and low-earners on the Lexis table. We then estimate the gap between high and low SES groups using APCTLAG for the differences as the dependent variables.

3. Results

3.1 Descriptive results

Table 1 summarises the variables used in this study. Next, we present the mean FESs of sugar products and non-alcoholic beverages by age, period and cohort (Figure 1). These figures are not adjusted for other variables. Sugar products make up a larger share of the grocery basket than non-alcoholic beverages. The age pattern was similar in both cases: FES was highest in the youngest age group, and it decreased with age. This finding is consistent with previous research. Stagnation in this trend between the ages of 30 and 44 has not been previously observed. The FES of sugar products remained stable at around 8% during the study period, with the exception of 1995, when it was significantly higher. The FES of non-alcoholic beverages rose from 1985 to 2001, after which it declined.

Figure 1 suggests that younger cohorts dedicate larger shares of their food baskets to sugar products and non-alcoholic beverages than older cohorts. However, those born after 1985 show a slight decline in the FES of sugar products. The abovementioned figures suffer from the APC identification problem. The rising cohort trend could be, at least in part, a result of the younger cohorts' age. In the same vein, the period trend could be obscured by the ageing population structure. Thus, we will attempt to model these variables in an APC setting.

3.2 Differences between birth cohorts

In the following analyses, the APCTLAG model accounted for age and period, given that the assumptions specified in the methods section are correct. We can therefore see how consumption has evolved across birth cohorts (Figure 2). The full models are presented in Table A1. The FES of sugar products rose from 6.3% to 8.9% in the cohorts born between 1915 and 1965. After the cohorts born after 1970, the estimates are more volatile. The FES of sugar products was the highest, at 9.5, in the 1980–1984 cohort.

The cohort pattern for non-alcoholic beverage consumption is more straightforward. In the oldest cohorts, the FES of non-alcoholic beverages hovered around 3.5%, but started

Description		Mean	Standard deviation	Median	Min	Max	Mode
Dependent variables							
Sugar FES	Share of total food expenditure of sugar products, %	7.93	6.76	6.59	0	100	
Beverage FES	Share of total food expenditure of non-alcoholic beverages, %	4.08	4.66	2.98	0	100	
Time variables							
Age 5	Age of head of household, five-year grouping	–	–	–	20–24	75–79	40–44
Year 5	Survey year, fitted to a five-year grouping	–	–	–	1985	2015	1995
Cohort 5	Birth year, five-year grouping	–	–	–	1920–1924	1990–1994	1945–1949
Independent variables							
EDU	Highest educational level of household. (1) primary, (2) secondary, (3) lower tertiary and (4) upper tertiary	–	–	–	1	4	1
Quartile	Household income quartile, equivalised with the OECDmod equivalence scale: 1–4	–	–	–	1	4	3

Table 1. Variables used in the study and summary statistics

rising in cohorts born after 1935–1939, reaching 6.5% in the youngest cohort. These modelling results support H1, which predicted that sugar products and non-alcoholic beverages occupy larger portions of the food baskets of more recent birth cohorts than preceding ones. Collectively, sugar products and non-alcoholic beverages comprised almost 10% of the food basket in the oldest cohort and over 15% in the youngest.

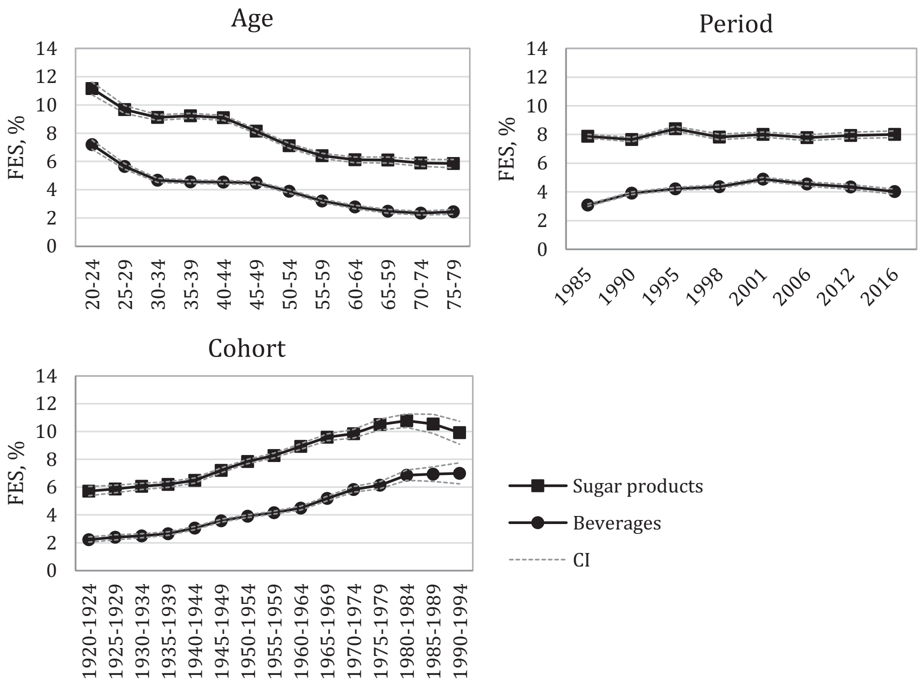
3.3 Age and period effects

According to the APCTLAG model, the FES of both sugar products and non-alcoholic beverages followed a declining age pattern. However, the stagnation in the age pattern that was observed in the descriptive plots between ages 30 and 45 was only apparent in the case of non-alcoholic beverages.

The zero-trended period effects showed a spike in the FES of sugar products in 1995. Between 1995 and 2010, the FES of sugar products was under the long-term trend. This coincides with the period (1999–2011) when no tax on sweets was in place. The FES share of non-alcoholic beverages was under the long-term trend at the start and at the end of the study period, but peaked over the trend at the turn of the millennium.

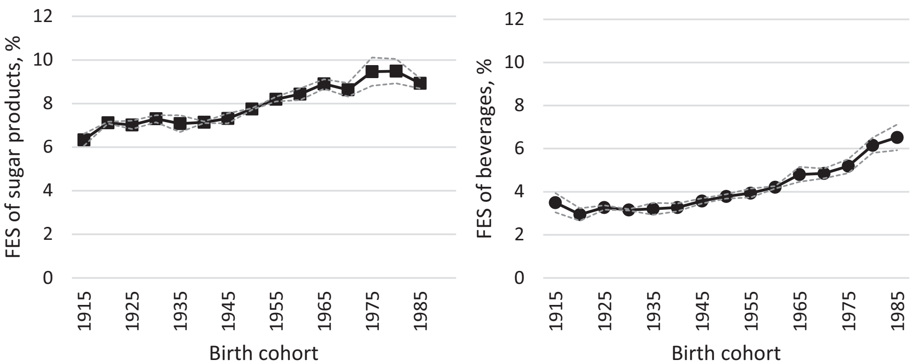
3.4 Socio-economic differences within birth cohorts

Figure 3 presents the gaps in the FES of sugar products between the lowest and highest income quartiles and between the primary and tertiary educated across birth cohorts.



Note(s): 95% confidence intervals are shown as dotted lines

Figure 1.
The average FESs of sugar products and non-alcoholic beverages by age, period and cohort



Note(s): Results obtained from APCTLAG models. The bootstrapped 95% confidence intervals are shown as dotted lines

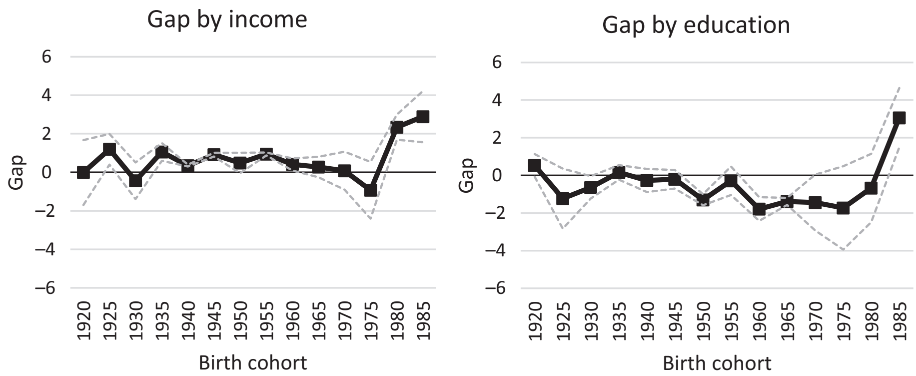
Figure 2.
Inter-cohort differences in the FESs of sugar products and non-alcoholic beverages

A positive gap means that the lower SES group had a higher sugar FES than the higher SES group, and vice versa. Generally, the lowest income quartile had a slightly higher FES of sugar products than the highest income quartile, or there was no significant difference. This is in line with previous research that has established that low-income groups tend to consume more sugar than high-income groups. The gap between income groups is widest in the two youngest cohorts. Thus, H2a is supported in the case of sugar products.

Figure 3 shows that in most birth cohorts, there was no significant gap in sugar consumption between education groups. In three cohort groups (1950–1954, 1960–1964 and 1965–1969), the FES of sugar was higher in the highly educated group. This result runs contrary to H2b, which predicted that sugar consumption would be higher in the less-educated group. However, in the youngest birth cohort, the primary educated had a higher FES of sugar products than the tertiary educated.

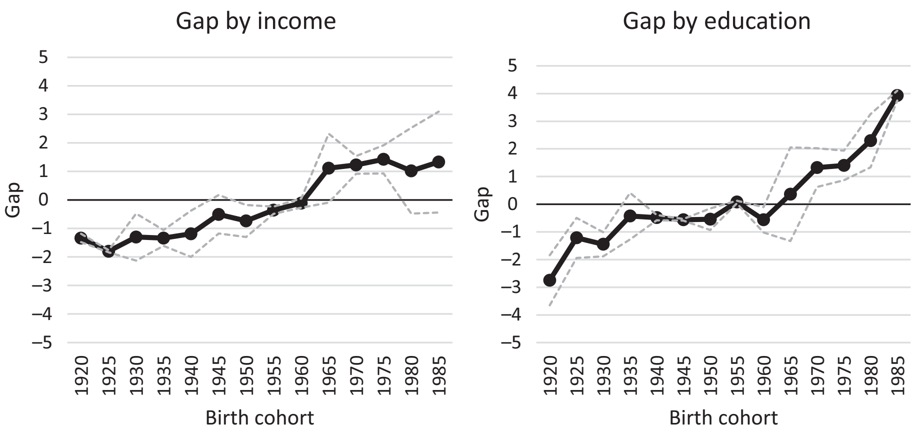
H3 predicted that the socio-economic gaps in sugar consumption have narrowed. The results show that the gaps did not evolve systematically in any direction. In fact, the differences in sugar expenditure widened in the youngest cohorts. Thus, in the case of sugar products, H3 is rejected.

Next, Figure 4 presents the gaps between the highest and lowest income quartiles and between the primary and tertiary educated in the FES of non-alcoholic beverages across birth cohorts. In the oldest cohorts, the FES of non-alcoholic beverages was larger in the high-



Note(s): Results obtained from APCTLAG models.The bootstrapped 95% confidence intervals are shown as dotted lines

Figure 3. Intra-cohort differences in the FES of sugar products by income quartile and education group. Gap represents the difference between lowest and highest income quartiles, and primary and tertiary educated



Note(s): Results obtained from APCTLAG models. The bootstrapped 95% confidence intervals are shown as dotted lines

Figure 4. Intra-cohort differences in the FES of non-alcoholic beverages by income quartile and education group. Gap represents the difference between lowest and highest income quartiles, and primary and tertiary educated

income and highly educated groups, but this gap narrowed towards cohorts born in the 1950s. In the birth cohorts born after the 1950s, the low-income and less-educated groups had an increasingly larger FES of non-alcoholic beverages than the high-income and highly educated groups. Thus, a first narrowing and then widening trend of socio-economic differences is observed. In particular, the gap between primary and tertiary education has grown.

Thus, H2a, H2b and H3 receive conditional support from the results. The lower SES groups had a larger FES of non-alcoholic beverages in the more recent birth cohorts (H2a and H2b), and socio-economic differences narrowed in the older birth cohorts (H3), but widened in the younger ones.

The sensitivity of the results presented above was tested by running the analyses with absolute monetary expenditures as dependent variables. These analyses revealed that the high-income and highly educated groups expended more euros than their counterparts on sugar products in cohorts born after the 1950s. However, these groups expended more euros on non-alcoholic beverages across all cohorts. It is natural that the higher SES groups have more money to spend, and their higher absolute spending might stem from either the quantity or quality of the products purchased. However, the lower FESs for sugar and non-alcoholic beverage products in the high SES groups towards the younger cohorts indicate that the totality of their food baskets are less occupied by sweets and drinks. The sensitivity of the results was further tested by running the FESs of sugar products and non-alcoholic beverages through the APC Intrinsic Estimator model (Yang *et al.*, 2004). The results were almost identical to those obtained from the APCTLAG model.

4. Discussion

This study used the Finnish household expenditure surveys to study how the consumption of sugar products and non-alcoholic beverages varied between birth cohorts and within birth cohorts by SES. The study utilized the recently developed APCTLAG model, which assumes that linear component of long-term change is caused by generations replacing one-another (Bar-Haim *et al.*, 2019). In addition, the model assumed the age effect to be similar across cohorts, an assumption backed up by the research literature. The results shed light on the role of sugar products and non-alcoholic beverages in the food budget. Money spent on these products reduces the money available for healthier, more nutritious alternatives. In addition, excess sugar consumption may promote obesity and hinder health. Thus, knowledge about how the roles of sugar products and non-alcoholic beverages in the food basket have changed as well as whether the related socio-economic differences have changed will help policymakers devise more informed policies towards better public health.

The results of this study highlight the usefulness of a cohort analysis informed by the life-course perspective and the diffusion of innovation concepts in the study of changing consumption patterns across birth cohorts. More recent birth cohorts grew up amidst an increasing variety of affordable sweets and soda pops, and the results of this study indicate that these products comprise a larger share of their food budgets than older cohorts. The FES of sugar products rose from the oldest cohort to those born in the 1980s. The FES of non-alcoholic beverages more than doubled between the oldest and youngest birth cohorts. Collectively, sugar products and non-alcoholic beverages made up almost 10% of the food basket in the oldest cohort and over 15% in the youngest. In absolute terms, in 2016 currency, this means an increase of 266 euros per year. The results coincide with the decline in milk consumption, which has been documented across birth cohorts in developed nations (Stewart *et al.*, 2012). The place of especially sugary drinks has changed in society during the life-courses of the birth cohorts studied. Whereas the earlier birth cohorts have grown up drinking water and milk, succeeding birth cohorts have grown up in a society where other beverages have been increasingly normalised. Nowadays beverages are the most prominent category of functional foods with a beverage existing for every vitamin and lifestyle (Corbo *et al.*, 2014). The lower share of sugar products and non-alcoholic beverages in the food baskets of earlier birth cohorts could relate to the low availability of these products in the earlier birth cohorts' youth and early adulthood. For example, consumption of many foods, including sugar products, was rationed in the 1940s due to Second World War.

Interestingly, the results obtained in the Finnish context differ from those in the United States and Norway. Using US survey data from 1982 to 1995, Blisard (2001) did not find a cohort effect in the consumption of sugar and sweets. In addition, a Norwegian study did not find a cohort effect in the consumption of soft drinks (Gustavsen and Rickertsen, 2014). When interpreting the results of the present study, it should be kept in mind that it is possible that sugar products and non-alcoholic beverages only occupy a larger share of the younger cohorts' food budget and that actual consumption does not increase to the same extent as the financial burden of these products.

When comparing high- and low-income households across birth cohorts, the low-income group had a higher share of sugar products in their baskets in several birth cohorts, especially the youngest. This is in line with previous research that has documented the association between lower SES and higher sugar consumption. The literature on socio-economic health inequalities emphasises unhealthy food as a source of comfort and pleasure to counter the stress of low resources and uncertainty, not to mention its attractiveness as a source of cheap calories (Pampel *et al.*, 2010). Historically, stocking up on calories was beneficial when tough times were anticipated (Laran and Salerno, 2013).

The relationship between education and sugar consumption varied more. In cohorts born in between 1950 and 1960, highly educated households had higher FESs of sugar products. Being well-educated has been linked to higher sugar consumption in Finland before (Ovaskainen *et al.*, 2013). It is not clear why this has been the case. Potential explanations could perhaps relate to time pressures or comfort seeking in the context of high occupational pressure. In the youngest birth cohort, lower education was associated with a higher share of sugar products in the food basket. The jump in the income and education gaps in the youngest birth cohort (born from 1985 to 1989) could be related to the steep increase in income inequality that happened right before this birth cohort reached adulthood and entered the labour force. After this steep rise during the turn of the millennium, income inequality has stayed stable (Karonen and Niemelä, 2020). This point of view emphasizes how periodical changes in the economic context can affect different birth cohorts variably depending on the stage of life they are in.

Diffusion dynamics were observed in the FES of non-alcoholic beverages. Socio-economic differences were bigger and more systematic in terms of direction in non-alcoholic beverage consumption than in sugar consumption. In the cohorts born before the 1950s, the FES of non-alcoholic beverages was higher in the high-income and highly educated groups. In the birth cohorts born after the 1950s, the low-income and less-educated groups had an increasingly larger FES of non-alcoholic beverages than their counterparts. Thus, a reversal of socio-economic differences was observed. This pattern is in line with the diffusion mechanisms proposed by the life-course perspective (Elder and George, 2016) and the diffusion of the innovation literature (Katz, 1999). The results are similar to what has been observed regarding SES differences in smoking. Pampel (2005) showed that in older cohorts, higher SES was a predictor of smoking, but the relationship has shifted, and in younger cohorts, lower SES predicts smoking. It seems that the share of sugar products in the food basket and the related socio-economic differences have not changed as much as in the case of non-alcoholic beverages. In light of the literature on the diffusion of consumption habits, it can be argued that the consumption of sugar products has already gone through the stages of socioeconomic diffusion that can be more starkly seen in non-alcoholic beverage consumption.

The bigger FESs of sugar products and especially non-alcoholic beverages among the more recent birth cohorts, especially the lower-SES households, imply that these food categories are an increasing financial burden to them. Previous research has also noted that fiscal policies aimed at reducing sugar intakes might be regressive, given that the consumption of sugar and sugar-sweetened beverages is more common among the poor (Kotakorpi *et al.*, 2011). The cohort and age differences observed in this study should be taken into account in the design of policies targeting the excess consumption of sugar products and beverages. The sugar intake of especially the young has raised concerns before (Azaïs-Braesco *et al.*, 2017). More generally, the results of this study underline the financial aspect of excess sugar consumption.

4.1 Strengths, limitations and future research

The central contribution of this paper is its application of cohort analysis to shed light on the differences between and within cohorts by SES. This was achieved with the APCTLAG method, which shows promise for further analyses in the field of consumption studies. Use of this methodology was enabled by the relatively long time series data provided by the Finnish HESs. The accompanying theoretical perspective of diffusion and the reversal of socio-economic differences also proved to be fruitful. Compared to the traditional self-report method used in dietary survey research generally, the fact that respondents in the HES were not reporting eating but rather purchases could make the data less subject to the bias for socially acceptable answering.

As for limitations, the present study was limited to analysing only one country, Finland. Further research should seek to obtain time-series data on sugar consumption patterns across multiple countries to allow for a comparative research design. Data from multiple countries and time points with relevant information about individual-level and/or contextual-level independent variables would allow for more explanatory analyses. Future research could also further the enterprise started here by obtaining data that have the individual as the observation unit as well as a more direct measure of the actual quantities of sugar products and beverages consumed. For example, part of sugar intake comes from alcoholic beverages, which were not studied in this article. The results presented here might indicate that the consumption of sugar products and non-alcoholic beverages has risen across cohorts, or that the financial burden of these products has risen. On a final note, purchase data do not tell if the product was bought for own consumption or to be gifted. Optimally, future research should take into account both the monetary aspect and actual consumption.

4.2 Conclusion

This study assessed how the FESs of sugar products and non-alcoholic beverages have changed across birth cohorts. In addition, this study measured how the socio-economic gaps in these FESs have changed across birth cohorts. The gaps were calculated between the first and last income quartile and between the primary and tertiary educated. The results showed that the FESs of sugar products and non-alcoholic beverages have risen across birth cohorts, more so in the case of non-alcoholic beverages. Socio-economic differences were more apparent in the case of non-alcoholic beverages. As non-alcoholic beverages have become more common in society, a reversal of socio-economic differences has occurred between birth cohorts: in birth cohorts born before the 1950s non-alcoholic beverages occupied a larger share of higher socio-economic groups' food baskets, but in those born after the 1950s, FESs were higher in the lower socioeconomic groups.

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Appendix

	Sugar products			Non-alcoholic beverages		
	Estimate	$\overline{X} - z\sigma\overline{X}$	$\overline{X} + z\sigma\overline{X}$	Estimate	$\overline{X} - z\sigma\overline{X}$	$\overline{X} + z\sigma\overline{X}$
1915	6.34	6.06	6.61	3.49	3.04	3.94
1920	7.12	7.08	7.16	2.95	2.65	3.24
1925	7.02	6.83	7.21	3.27	3.17	3.37
1930	7.30	7.14	7.46	3.16	3.13	3.19
1935	7.08	6.70	7.46	3.20	2.93	3.48
1940	7.14	7.11	7.17	3.28	3.09	3.46
1945	7.32	7.09	7.55	3.58	3.46	3.69
1950	7.75	7.71	7.79	3.78	3.68	3.89
1955	8.20	8.09	8.30	3.94	3.74	4.14
1960	8.43	8.16	8.70	4.21	4.15	4.26
1965	8.90	8.68	9.12	4.81	4.46	5.15
1970	8.63	8.32	8.94	4.85	4.62	5.08
1975	9.47	8.82	10.11	5.19	4.87	5.51
1980	9.48	8.93	10.04	6.16	5.81	6.51
1985	8.93	8.70	9.17	6.52	5.93	7.12
20	2.71	1.47	3.94	1.98	1.63	2.32
25	1.33	1.23	1.43	0.95	0.77	1.13
30	0.89	0.68	1.10	0.31	0.09	0.53
35	0.71	0.57	0.86	0.50	0.40	0.60
40	0.60	0.10	1.10	0.48	0.33	0.63
45	−0.13	−0.24	−0.02	0.57	0.47	0.68
50	−0.62	−0.77	−0.47	−0.04	−0.16	0.09
55	−1.25	−1.33	−1.17	−0.40	−0.48	−0.32
60	−1.27	−1.62	−0.92	−0.70	−0.88	−0.52
65	−0.99	−1.14	−0.85	−0.96	−0.99	−0.93
70	−1.23	−1.56	−0.91	−1.10	−1.11	−1.09
75	−0.74	−1.94	0.46	−1.59	−1.82	−1.36
1985	0.08	0.03	0.14	−0.50	−0.62	−0.38
1990	−0.19	−0.28	−0.09	0.09	−0.04	0.22
1995	0.50	0.43	0.57	0.10	0.02	0.18
2000	−0.39	−0.49	−0.29	0.52	0.46	0.58
2005	−0.19	−0.40	0.02	0.29	−0.04	0.63
2010	−0.02	−0.05	0.01	0.04	−0.16	0.25
2015	0.20	0.09	0.31	−0.54	−0.56	−0.51

Table A1. Estimates and their confidence intervals from the APCTLAG model for the food expenditure shares of sugar products and non-alcoholic beverages

Table A2. Estimates and confidence intervals from the APCTLAG model for the gaps between the lowest and highest income and education groups in the food expenditure shares of sugar products and non-alcoholic beverages

	Sugar products						Non-alcoholic beverages					
	Gap between first and fourth income quartile			Gap between primary and tertiary educated			Gap between first and fourth income quartile			Gap between primary and tertiary educated		
	Estimate	$\overline{X}-z\sigma\overline{X}$	$\overline{X}+z\sigma\overline{X}$	Estimate	$\overline{X}-z\sigma\overline{X}$	$\overline{X}+z\sigma\overline{X}$	Estimate	$\overline{X}-z\sigma\overline{X}$	$\overline{X}+z\sigma\overline{X}$	Estimate	$\overline{X}-z\sigma\overline{X}$	$\overline{X}+z\sigma\overline{X}$
1920	−0.011	−1.7	1.677	0.525	−0.077	1.127	−1.333	−1.481	−1.185	−2.749	−3.653	−1.845
1925	1.193	0.394	1.991	−1.233	−2.828	0.362	−1.797	−1.834	−1.759	−1.216	−1.942	−0.49
1930	−0.437	−1.391	0.518	−0.636	−1.224	−0.049	−1.303	−2.127	−0.48	−1.451	−1.889	−1.012
1935	1.058	0.601	1.515	0.162	−0.223	0.548	−1.334	−1.612	−1.057	−0.429	−1.271	0.414
1940	0.348	0.299	0.397	−0.27	−0.88	0.339	−1.183	−1.995	−0.371	−0.483	−0.58	−0.385
1945	0.918	0.814	1.021	−0.203	−0.696	0.291	−0.502	−1.177	0.173	−0.562	−0.587	−0.536
1950	0.484	−0.049	1.017	−1.294	−1.592	−0.996	−0.736	−1.297	−0.176	−0.54	−0.931	−0.15
1955	0.949	0.877	1.022	−0.282	−1.039	0.475	−0.36	−0.484	−0.236	0.079	0.029	0.129
1960	0.407	0.092	0.722	−1.791	−2.421	−1.161	−0.11	−0.273	0.053	−0.564	−1.024	−0.103
1965	0.275	−0.255	0.804	−1.384	−1.574	−1.195	1.116	−0.093	2.325	0.359	−1.334	2.052
1970	0.08	−0.904	1.064	−1.444	−2.931	0.042	1.226	0.916	1.536	1.326	0.628	2.024
1975	−0.931	−2.404	0.543	−1.725	−3.942	0.492	1.423	0.929	1.917	1.4	0.865	1.936
1980	2.347	1.692	3.001	−0.667	−2.482	1.148	1.024	−0.479	2.527	2.294	1.332	3.256
1985	2.892	1.564	4.22	3.068	1.496	4.64	1.329	−0.439	3.097	3.924	3.745	4.103
25	1.247	0.373	2.122	−0.984	−2.825	0.857	−1.06	−1.458	−0.661	−2.209	−2.97	−1.448
30	0.523	0.375	0.671	−0.914	−1.061	−0.768	−0.686	−1.495	0.123	0.716	0.114	1.318
35	−0.683	−1.588	0.221	0.083	−0.035	0.201	0.053	−0.561	0.668	−1.344	−1.64	−1.048
40	−0.099	−0.5	0.302	−0.158	−0.495	0.179	−0.08	−0.083	−0.077	−0.265	−0.327	−0.204
45	−1.012	−1.644	−0.38	−0.646	−0.811	−0.482	0.368	0.152	0.583	−0.089	−0.606	0.427
50	−0.276	−0.626	0.074	0.381	0.068	0.694	0.009	−1.026	1.045	−0.102	−0.817	0.612
55	−1.241	−1.445	−1.036	0.096	−0.508	0.7	0.402	0.33	0.474	0.326	0.053	0.599
60	−0.843	−1.762	0.076	1.655	1.294	2.015	−0.36	−0.665	−0.054	0.352	0.207	0.496
65	−0.104	−0.702	0.495	0.388	−0.065	0.84	0.432	0.007	0.858	0.939	0.424	1.453
70	−0.387	−1.186	0.412	0.1	−0.776	0.975	0.921	−1.964	3.805	1.678	0.031	3.324
1985	0.416	0.318	0.514	0.114	−0.411	0.639	0.285	−0.028	0.599	0.507	0.174	0.84
1990	−0.176	−0.484	0.132	0.07	−0.212	0.352	−0.294	−0.483	−0.104	0.136	0.051	0.22
1995	−0.077	−1.093	0.939	−0.432	−1.322	0.459	−0.139	−0.281	0.004	−0.591	−0.929	−0.253
2000	−0.699	−1.584	0.185	0.001	−0.024	0.025	−0.214	−0.534	0.106	−0.072	−0.154	0.01
2005	0.513	−0.062	1.089	0.241	−0.682	1.164	0.233	0.151	0.316	−1.128	−1.663	−0.593
2010	−0.239	−1.448	0.97	0.206	0.162	0.25	0.486	0.111	0.861	1.112	0.864	1.36
2015	0.261	−1.182	1.705	−0.201	−0.497	0.096	−0.358	−0.87	0.154	0.036	−0.254	0.326

About the author
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