



MASTER THESIS

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„Unveiling the Nutrition Transition: The Role of Sugar Content in Sugar-Sweetened Beverages in Economic Development and Sugar Consumption Patterns“

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On my honour as a student of the Diplomatische Akademie Wien, I submit this work in good faith and pledge that I have neither given nor received unauthorized assistance on it.

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Abstract

The overconsumption of sugar is a grave problem that is increasingly causing immense human and economic costs, especially in low- and middle-income countries. The theory of the nutrition transition describes the process of changes in the food system and food culture in relation to the economic development of a country. According to this theory countries first experience a vast increase in sugar consumption, which reaches a certain threshold after which less sugar is consumed. Adding to this theory, this master thesis aims to explore whether these patterns in economic development and sugar consumption are intermediated by a factor of “local preference for sugar”. As sugar preference is not a measurable variable, this thesis suggests utilizing the local demand for sugar in a globally comparable product as a proxy variable. Coca Cola, Fanta Orange, and Sprite are used as these indicators because they are glocalised products – they are comparable worldwide due to their global availability and global brand identity, however, they have regionally differentiated recipes. In two parts, it is first explored whether Coca Cola, Fanta Orange, and Sprite are good proxy variables. For this, the sugar content in Coca Cola, Fanta Orange, and Sprite from more than 120 countries was collected by the author. The data is then tested for internal validity, country income level distribution, regional distribution, and connection to the average sugar consumption per country. Subsequently, a model of the nutrition transition in regard to sugar was composed, and the variables of Coca Cola, Sprite and Fanta Orange were included. It is found that although there are sound theoretical reasons why this addition to economic development literature might work, there is no statistically significant effect, which would lead the author to believe to have found an accurate independent indicator of sugar preference. The sugar content in the three sugar-sweetened beverages does not conform per country nor form consistent geographical or economic patterns. Further, only Coca Cola, a highly consistent brand in terms of sugar content, is statistically significant in the modelling of the nutrition transition. Therefore, it is concluded that no new addition to the nutrition transition theory could be found in this master thesis. In the Discussion, several reasons for these results are given, including limitations of the nutrition transition theory, lacking availability of data on sugar consumption, which includes a more diversified look into countries, and limitations to the study design itself.

Abstract

Übermäßiger Zuckerkonsum ist ein schwerwiegendes Problem welches zunehmend immense menschliche und wirtschaftliche Kosten verursacht. Ergänzen zu der Theorie der globalen Ernährungsumstellung (nutrition transition theory) soll in dieser Masterarbeit untersucht werden, ob die Entwicklung des globalen Zuckerkonsums durch einen Faktor der "lokalen Zuckerpräferenz" beeinflusst wird. Da die Zuckerpräferenz keine messbare Variable ist, wird in dieser Arbeit vorgeschlagen, die lokale Nachfrage nach Zucker in einem weltweit vergleichbaren Produkt als Ersatzvariable zu verwenden. Als Indikator dafür wird der Zuckergehalt in den globalen Produkten Coca Cola, Fanta Orange, und Sprite verwendet. In zwei Teilen wird zunächst untersucht, ob Coca Cola, Fanta Orange, und Sprite eine gute Proxy-Variable sind. Dazu wurde der Zuckergehalt in Coca Cola, Fanta Orange, und Sprite aus mehr als 120 Ländern von der Autorin erhoben. Die Daten werden dann auf interne Validität, Verteilung des Einkommensniveaus der Länder, regionale Verteilung und Zusammenhang mit dem durchschnittlichen Zuckerkonsum pro Land getestet. Anschließend wird ein Modell der Ernährungsumstellung in Bezug auf Zucker erstellt, in das die Variablen von Coca Cola, Sprite, und Fanta Orange einbezogen wurden. Es wird festgestellt, dass es zwar stichhaltige theoretische Gründe dafür gibt, warum diese Ergänzung der Literatur zur wirtschaftlichen Entwicklung funktionieren könnte, aber kein statistisch signifikanter Effekt vorliegt. In der Diskussion werden mehrere Gründe für diese Ergebnisse angeführt, diese sind unter anderem die Grenzen der Theorie des Ernährungswandels, die mangelnde Verfügbarkeit von Daten zum Zuckerkonsum, die einen breiteren Blick auf die Länder ermöglichen, und die Grenzen des Studiendesigns selbst.

1. Introduction

Sugar is commonly described as “empty calorie”, however, it is everything but. The overconsumption of sugar has severely elevated mortality and morbidity in the general population worldwide (Santos et al., 2022). In recent years, mounting evidence has shown that unhealthy diets are the main contributors to non-communicable diseases (Baker & Friel, 2014). Further, overconsumption of sugar not only leads to obesity but also liver toxicity, dental diseases, type 2 diabetes, higher risks of heart attacks, gout, fatty liver diseases, metabolic diseases, and a multitude of other chronic diseases (Bes-Rastrollo et al., 2016; Headey et al., 2023; Lustig et al., 2012; Malik & Hu, 2022; Mchiza et al., 2016; Naghavi et al., 2024; Popkin & Hawkes, 2016; Santos et al., 2022; Tagesschau, 2018). Some studies have even found that sugar has addictive effects, which are similar to alcohol addiction (Lustig et al., 2012).

The focus of this Master's Thesis will be the connection between economic development and sugar consumption. Studies show that the average sugar consumption in a country rises immensely with increasing economic development. This quickly leads to overconsumption of sugar and causes significant human and economic costs (Kearney, 2010). It is relevant to understand this relationship in detail, as a better understanding of the connection between the average income and living standards in a country on the one hand and its citizens' proclivity towards sugar consumption on the other might help predict developments of public health.

In this master thesis, the demand for sugar will be researched, utilizing the nutrition transition theory. This theory posits that through economic developments, food and social systems changes lead individuals to consume more sugar. Food preferences and choices are, of course, influenced by social circumstances and attitudes. Notwithstanding, growing evidence shows that preferences are essentially linked to economic variables.

While other studies have intensively studied the affordability of sugar-filled products or their overall consumption, little research has been done on a nation's average demand for sugar in a single product. This is where this master's thesis comes in.

A factor in this transition, which has so far not been researched, is whether the taste for sugar or preference for sugar changes similarly to overall sugar consumption. To conceptualise this “preference for sugar” in this master thesis, the demand for sugar in a comparable product will be utilized. This thesis explores whether the sugar content of a comparable product in different markets can be used as a proxy for a regional sugar demand or for a regional sugar preference.

This paper adds to the existing literature on food preferences and development by trying to find a measurable variable indicating the average sugar demand per sugar product in a country's population. This effort is underpinned by the hypothesis that the regionally determined demand for the sugar content in a globally comparable product is an interesting confounding variable, which has not yet been studied in the relation between sugar consumption and a country's economic development.

This is done by investigating the sugar content of Coca Cola, Fanta Orange, and Sprite, all brands under the umbrella of the Coca Cola Company. This data is then used as an indicator of regional sugar demand. The Coca Cola Company is a global corporation that sells its products in nearly all countries worldwide, with regionally varying recipes. The sugar content within those recipes is easily accessible, which makes it an interesting, innovative factor comparable between different countries and markets. A more in-depth theoretical justification of the suitability of this variable is given at a later point.

In the context of those considerations, the research question of this master thesis is:

“In how far is the demand for sugar content in a globally comparable product a significant factor in the relation between economic development and sugar consumption?”

This research question prompts two sub-questions:

1. “In how far is the sugar content in Coca Cola, Sprite and Fanta Orange a good indicator for the national demand for sugar or sugar preference?”
2. “In how far are these variables statistically significant factors in the relationship between the average national sugar consumption and economic development?”

This master thesis hypothesized that firstly, the sugar content of Coca Cola, Sprite, and Fanta Orange are good indicators for the preference of the local population in sugar content in products. This hypothesis was drawn from the fact that these specific beverages are so-called “glocalised” products, which are manufactured locally and localized, so changed to fit the local market characteristics.

Secondly, it hypothesizes that the relationship between the average national sugar consumption and the economic development of a country is, in line with the theory of the nutrition transition, mediated by this measure of demand for sugar in a product, and thus that statistically significant results can be found.

These hypotheses will be discussed in more detail later in this thesis.

The thesis will progress as follows. At first, the relevance of this research will be laid out clearly, followed by a literature review of studies that address the nexus between diets and economic development. Subsequently, the central theory of the “nutrition transition” will be

discussed, laying the foundation for the theoretical models developed in the later Methods sections. Then, the two research questions will be addressed separately. At first, Sub-Question 1's Utilized Variables, Methods, and Results will be discussed before the same is done for the second sub-question. The outcomes of these two analyses and their significance in relation to the theoretical model and the research question will be explored in the Discussion and Conclusion section. This section also includes a few paragraphs about the limitations of this study. Finally, a Bibliography will round off the paper.

For the purpose of this thesis a sugar-sweetened beverage is defined as a beverage which contains more than 20kcal per 100ml, following the Euromonitor definition. This definition includes beverages such as sodas, sports drinks, sweetened iced tea, ready-to-drink coffee and tea, fruit and vegetable juices, energy drinks, and sugar-sweetened syrups, such as Ribena (Singh et al., 2015; Kleiman et al., 2012). Many products made by the Coca Cola Corporation are thus prime examples of sugar-sweetened beverages, including Coca Cola, Sprite and Fanta Orange.

2. Relevance

This research is highly relevant because, over the last half a century, sugar consumption has tripled worldwide. In particular, the consumption of sugar-sweetened beverages has increased manifold. Ever since the 1990s, the increasing availability, acceptability and affordability of sugar-sweetened beverages have contributed to high numbers of consumption (Mchiza et al., 2016).

The effects of sugar overconsumption are responsible for grave human and economic costs. It is estimated, for example, that obesity alone costs the German healthcare system around 63 billion Euros per year. This is equal to the cost incurred by the consumption of tobacco and highly exceeds the costs caused by the overconsumption of alcohol (Tagesschau, 2018). According to the United Nations, chronic non-communicable diseases have recently overtaken the number of infectious diseases and are essentially contributing to 35 million deaths per year (Lustig et al., 2012). Non-communicable diseases thus account for 22% of deaths in 2018, as well as 15% of disability-adjusted life years of individuals older than 18 years (Headey et al., 2023).

The described health problems are exacerbated in low- and middle-income countries, as these are affected by the so-called double burden of malnutrition, which describes a sharp rise in obesity rates even as undernutrition persists (Headey & Alderman, 2019; Naghavi et al., 2024). High consumption of sugar-sweetened beverages has fuelled obesity epidemics, which by now affect nearly all middle- and high-income countries (Malik & Hu, 2022). Ever since the 1980s,

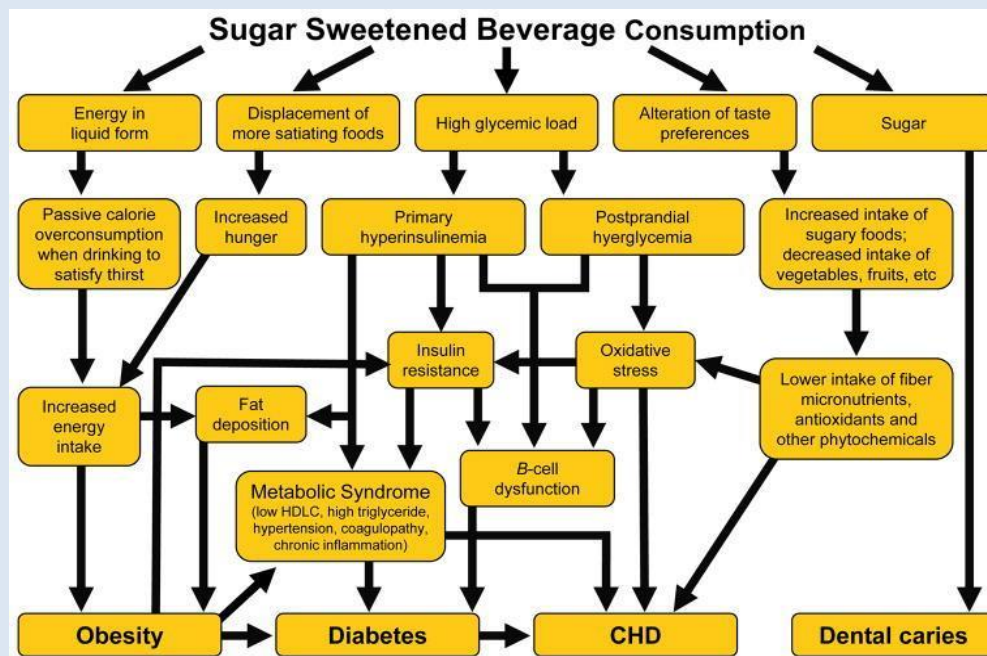
the average BMI has increased significantly in nearly every country in the world, which has become a major public health concern (Finucane et al., 2011).

Over the last decades, an increasing number of countries have adopted “Western diets”, which are dominated by highly processed food. This diet contains, on average, a bigger amount of sugar, fats, and salts (Lustig et al., 2012). The rising obesity rate in low-income countries worsens the often already precarious situation of health systems in countries where infectious diseases and undernutrition are still important policy problems (Mchiza et al., 2016). Lower-income countries are less equipped to deal with non-communicable diseases (Lustig et al., 2012).

Sugar-sweetened beverages are a particularly important and dangerous vector of sugar overconsumption (Baker & Friel, 2014). To further illustrate this point, Figure 1 provides an overview of some of the patterns, through which the consumption of sugar-sweetened beverages causes negative health outcomes (G. M. Singh, Micha, Khatibzadeh, Lim, et al., 2015; G. M. Singh, Micha, Khatibzadeh, Shi, Lim, Andrews, Engell, Ezzati, Mozaffarian, & Group (NutriCoDE), 2015).

Figure 1

Health effects of sugar-sweetened beverage consumption



Note. Sourced from G. M. Singh, Micha, Khatibzadeh, Lim, et al., 2015, p. 112.

A recent study estimated that, yearly, about 184.000 deaths are directly attributable to the consumption of sugar-sweetened beverages. Most of these were caused by diabetes mellitus, followed by cardiovascular diseases and different types of cancers. A large majority of 70.9%

of these estimated deaths occur in middle-income countries, followed by 24.1% in high-income countries and only 5% in low-income countries. While overall, only around 2% of deaths caused by diabetes mellitus, cardiovascular disease, and cancer can be related to the high consumption of sugar-sweetened beverages, the connection becomes significantly more visible if differentiated by subpopulation. For example, the death of about 33% of Mexican men in the ages 20 to 44 can be attributed to sugar-sweetened beverages (G. M. Singh, Micha, Khatibzadeh, Lim, et al., 2015).

These results are also particularly worrying as sugar-sweetened beverages disproportionately and predominantly impact the youth. The consumption of sugar-sweetened beverages of younger people is much higher than that of older people (Bleich et al., 2018; Chatelan et al., 2021; G. M. Singh, Micha, Khatibzadeh, Lim, et al., 2015). Currently, about one out of every 10 of all diabetes mellitus deaths worldwide can be attributed to the consumption of sugar-sweetened beverages. If there is a birth cohort effect, the global morbidity and mortality attributable to sugar-sweetened beverages may increase steeply as the current youth ages into a higher risk category of chronic diseases while continuing their high consumption of sugar-sweetened beverages (G. M. Singh, Micha, Khatibzadeh, Lim, et al., 2015).

3. Literature Review – Economic Development and Sugar Consumption

In current economic literature, there are several works which discuss the nexus between economic development and sugar. Especially several countries, namely China, India, Brazil, the USA and Mexico have been investigated intensively (Du et al., 2014; Garzillo et al., 2023; Shang et al., 2012; Shetty, 2002; Stern et al., 2014; Taylor et al., 2011). Unfortunately, studies covering the whole world are rare. Summarising broadly, a positive correlation between economic development and sugar consumption has been found, with a certain plateauing effect (e.g. Malik & Hu, 2022). According to these papers, low-income countries consume increasingly more sugar with growing economic prosperity. The acceleration of sugar consumption is the highest in middle-income countries and stagnates or even falls in high-income countries (Baker & Friel, 2014; Kearney, 2010).

In low- and middle-income countries, income constraints still strongly dictate food consumption. Until a certain income threshold is reached, food choices between individuals are identical, irrespective of their preferences, as they are driven by calorie considerations (Boom et al., 2015; Drewnowski, 1997). With growing economic development, food choices are then often influenced by considerations of taste, social status, and convenience. On a household level, it was found by Headey et al. that the consumer preferences for high sugar foods are quite strong and rise proportionally with household income (Headey et al., 2023).

Another behavioural economics study by Almås et al. has found that, as households become richer, they adjust their food consumption from calorie-dense food to more expensive food with better taste, so towards food with higher sugar content (Almås et al., 2019).

According to Popkin, theorized from a rational economic theory point of view, the current food market liberalization and globalization will inevitably result in global diets with higher sugar content for three reasons. First, it has been observed that a high preference for sugar or a sweet taste is present in all societies around the globe, which leads experts to conclude that this preference is innate to humans. Secondly, the consumption preferences of individuals depend highly on their income. With a change in income, consumer preferences change. With additional income, high-fat and high-sugar foods are purchased. Both of these facts will be discussed in more detail later. Third, globalized access to food helps to lower the real prices of basic commodities such as sugar, which again changes the composition of diets and decreases the cost for producers to offer well tasting, sugary, processed food (Popkin, 2003).

Rising national income is, in fact, associated with a substantial increase in the consumption of less nutritious foods. This holds true particularly for highly processed food with a high sugar content and an increasing consumption of sugar-sweetened beverages (Baker & Friel, 2014; Fanzo & Davis, 2021). Whilst overconsumption is a problem in general, many studies have indicated that sugar-sweetened beverages are a particularly potent vector in the overconsumption of calories (Kleiman et al., 2012; Pereira et al., 2014, 2015). Added sugar is utilised to produce hyper-palatable, durable and transportable products, which are often highly branded and advertised as part of an affluent, desirable “food culture” (Drewnowski, 2007). This is described in more detail in the Theory section of this thesis.

While it is clear that consumers in lower-income countries develop a higher demand for sugar with increasing economic gain, it seems to be that this effect plateaus with increasing development of a country. Whilst economic development increases the accessibility and availability of sugar, according to a recent study, the intake of sugar-rich beverages in the USA has plateaued and even declined modestly. This trend has also been observed in other high-income countries in terms of sugar consumption (Baker & Friel, 2014).

It was further observed that the consumption of calories through sugar grew 127% in developing countries between 1963 and 2003. In some countries, this consumption increase was even higher; for example, in China, the proportion of calories consumed through sugar grew 305% in the same time span. Sugar consumption rose considerably in Africa, Latin America, and Asia. In high-income countries, however, the consumption of calories through sugar shrank 6% in 2003 compared to 1963 (Kearney, 2010).

The analysis of this data further shows that this trend depends more on the country's economic development than on the region it is situated in. Although sugar consumption is declining overall in North America and Europe, in poorer European countries, like former Soviet countries, there have been modest gains over the 40 years covered in the investigation (Kearney, 2010).

Popkin found that in countries with a lower income and less urbanisation the intake of sugar increases sharply with rising per capita income. According to his model, the share of sugar of the daily caloric intake rose from 5% to 15% through economic advancement. In the case of a country with a higher income and higher urbanisation, the share of sugar of the total caloric intake is higher to begin with at around 15% and, with per capita income growth, stays the same or even declines slightly, from 15% to about 10% (Popkin, 2009).

Another very important shift in sugar consumption along the nutrition transition is the changing of the source of calories. Whilst, at first, sugar is mainly consumed through food, sugar-sweetened beverages play an increasingly important role as a country moves through the nutrition transition. Carbonated sugar beverages have been found to be one of the most significant vectors in that development (Baker & Friel, 2014). The brands of Coca Cola and Pepsi Cola are particularly responsible for this shift (Baker et al., 2020). In a study of Mexican individuals, it was even found that they consumed up to one-fifth of their daily caloric intake through sugar-sweetened beverages, this proportion having doubled between 1999 and 2006 (Popkin, 2009).

This is especially relevant as sugar-sweetened beverages do not, per se, have nutritional use, as they do not satiate substantially. Thus, researchers have argued that calories from sugar-sweetened beverages are one key factor in the emerging global energy imbalance and the consequent overconsumption of sugar (Mourao et al., 2007).

The consumption of sugar-sweetened beverages, as well as other processed products containing high sugar contents follows the same pattern as overall sugar consumption. In general, the consumption of sugar-sweetened beverages grows as consumer income grows (Blecher et al., 2017) until a certain threshold is reached. The consumption of sugar-sweetened beverages is the highest in middle-income countries, especially in Latin America and the Caribbean (Malik & Hu, 2022), compared to low- and high-income countries (Ferretti & Mariani, 2019; Malik & Hu, 2022; G. M. Singh, Micha, Khatibzadeh, Shi, Lim, Andrews, Engell, Ezzati, Mozaffarian, & Group (NutriCoDE), 2015). Furthermore, Baker and Friel found that the consumption of high sugar products, especially sugar-sweetened beverages, has, in the period between 1999 and 2012, rapidly increased in these low-income and middle-income countries. In high-income countries, consumption slowed or even declined (Baker & Friel, 2014).

According to a study by Popkin and Hawkes, the consumption of sugar-sweetened beverages between 2009 and 2014 decreased in North America, Australasia and Western Europe, but kept increasing in other regions of the world. The daily sold calories per capita of all sugar-sweetened beverages show some variation between different types of beverages. Especially in North America, the sales of caloric carbonated soft drinks have decreased, whilst the sales of fruit juice and sports drinks have increased (Popkin & Hawkes, 2016). Rising economies like China have, within the studied time period, increased their sugar-sweetened beverage consumption greatly. Consumption increased significantly from a very low initial level, which was positively related to obesity, especially among children (Popkin & Hawkes, 2016; Shang et al., 2012).

In a review of beverage consumption in 187 countries, Singh et al. found that, with an average daily consumption of 1.22 servings of 8 ounces a day, the consumption was higher in upper middle-income countries and lower middle-income countries (0.95 servings a day) than in high-income countries (0.71 servings a day) or low-income countries (0.56 servings a day). The consumption was highly heterogeneous between geographical regions. Nevertheless, it could be observed that the regions of the Caribbean (3.0 servings per day), Latin America (1.61 servings), and North America (0.83 servings) had a particularly high consumption. The country with the highest consumption of sugar-sweetened beverages from this sample was Trinidad and Tobago, closely followed by Suriname, Cuba, Barbados, Saint Vincent and the Grenadines, Grenada and the Dominican Republic. The lowest consumption rates in this study were found in North Korea and Azerbaijan. Between 1990 and 2010, the general sugar-sweetened beverage consumption increased, especially in the Caribbean, Latin America and Southeast Asia (G. M. Singh, Micha, Khatibzadeh, Shi, Lim, Andrews, Engell, Ezzati, Mozaffarian, & Group (NutriCoDE), 2015).

This research is further backed up by several regional studies. Many studies from recent years provide regional reviews of dietary quality in connection with sugar-sweetened beverages as well as their levels of consumption (Du et al., 2014; Ferretti & Mariani, 2019; Imamura et al., 2015; Malik & Hu, 2022; Pereira et al., 2014; Popkin, 2017; G. M. Singh, Micha, Khatibzadeh, Shi, Lim, Andrews, Engell, Ezzati, Mozaffarian, & Group (NutriCoDE), 2015; Stern et al., 2014; Taylor et al., 2011; Zhai et al., 2014).

Another trend in the consumption of sugar-sweetened beverages in high-income countries is the increase in substitution of these drinks through diet alternatives. For example, in the US, diet beverage brands make up about one-third of the sugar-sweetened beverage market (Kleiman et al., 2012). The intake of full-calorie sugar-sweetened beverage has declined ever since 2000 amongst virtually every age group and gender, whilst the consumption of low-calorie drinks has increased (Storey, 2010; Y. C. Wang et al., 2018). In high-income countries,

carbonated sugar-sweetened beverages are being replaced by energy drinks, ready-to-drink tea, fruit juice and sports drinks with less sugar content. Baker et al. have found that this development is a result of policy action taken against sugar-sweetened beverages and increasing public health consciousness among consumers (2020).

4. Theory – the Nutrition Transition

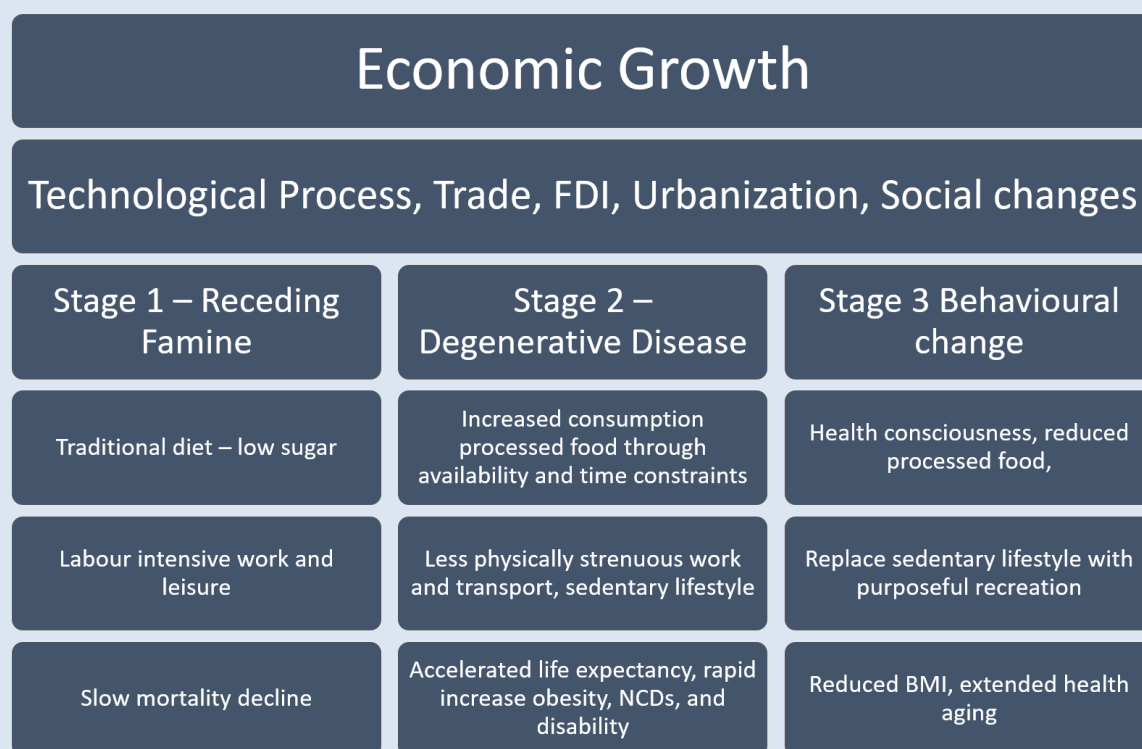
Based on the existing research collected and summarised in the literature review, the central theoretical concept this Master Thesis utilizes is the so-called “nutrition transition”. In the following section, this theory will be explored in detail in order to lay a theoretical basis for the variables included in the later statistical analysis.

Originally stemming from nutrition and social sciences, this theory has now increasingly been used in the measure of the economic development and liberalisation of countries. Put simply, it describes the change of food culture and consumption caused by increases in national income and urbanisation (Baker et al., 2020; Haddad et al., 2016; Hawkes, 2006; Popkin, 2017; Popkin & Gordon-Larsen, 2004).

Typically, countries go through several predictable stages of the nutrition transition, starting with a phase of receding famines. With growing income, the typical agrarian, starch-heavy, and grain-based diets of these countries gradually change towards a more “Western” diet, which contains more added sugar, fat, animal products, and processed food. Experts have also called this continuous development “coca-colonization” or McDonaldization. In the second “degenerative disease” stage, these changed diets in conjunction with changed physical activity patterns, lead to the development of new disabilities and diseases in the population. In this state, degenerative diseases become apparent, non-communicable diseases arise more often, obesity emerges on a substantial level, and bone density problems emerge. In the third stage, policy interventions and a greater awareness of health in the population address these negative changes and remedy them partially. The government and individuals of these, mostly high-income countries, realise the high financial and health burden of unhealthy diet and physical activity patterns and counteract this through policies and individual activity. Sedentarism is replaced through purposeful physical activity in leisure time and diet products become widespread (Baker et al., 2020; Drewnowski, 1997; Hawkes et al., 2009; Popkin, 2003). This process is summarised in the following Figure 2.

Figure 2

Schematic Representation of the Nutrition Transition



Note. This figure has been modelled by the author after Popkin, 2003 and Popkin & Gordon-Larsen, 2004.

The nutrition transition works through expansion and substitution effects. At first, the expansion effect occurs, in which cheaper available food sources increase the overall consumed calories and thus serve for increased energy supplies. This development takes place in any country as soon as this processed food arises, no matter their grade of development. In the second so-called substitution stage, the consumption patterns change to include more processed food, oils, sugar and animal products. Traditional carbohydrate filled foods, such as roots or cereals, are increasingly replaced. This development is dependent on the economic situation of the country and influenced by traditions and culture (Kearney, 2010).

Although this nutrition change is well established in Asia, there has not been an economic study yet which examined expansion and substitution effects on a global level (Lee et al., 2012).

At the basis of this transition and central to the nexus between globalization and diet are social system and food system changes, which will be discussed in more detail in the following subsections. The discussed food system changes are the global trade in food, technology changes, foreign direct investment in food retailing and processing, and advertisement and marketing. The social system changes discussed are changes to physical activity patterns,

urbanisation, cultural changes and influences as well as global food retail market restructuring (Hawkes, 2006; Hawkes et al., 2009; Kearney, 2010; Popkin, 2009, 2009; Popkin & Gordon-Larsen, 2004).

4.a Food System Changes

Since the 1950s, ultra-processed foods have become key ingredients of the average diet in high-income countries. Following the large-scale globalization of the food market, which started approximately in the 1970s, ultra-processed foods have increasingly become available worldwide (Baker et al., 2020). Producers, processors, manufacturers, fast food chains and retailers shape food systems in ways that alter availability, price, nutritional quality, desirability and ultimately consumption (Hawkes, 2006). Several factors have caused this development, namely trade, foreign direct investment, manufacturing technologies and marketing.

4.a.i Trade

Food markets have become ever more global with the increasing globalization of world trade (Baker et al., 2020). According to rational economic theory, globalization increases global efficiency, as areas with a comparative advantage are more successful and thus specialize in this product. This holds true especially in agriculture (Pingali, 2007).

Since the 1970s and -80s, low- and middle-income countries have structurally adjusted their agricultural policies and liberalized trade. This was accelerated through international agreements, like the WTO General Agreement on Tariffs and Trade. Through this, the food market developed into an international one (Hawkes, 2006). Through the resulting international trade, food supplies have become cheaper to produce, more efficient, more consistent, and thus cheaper for consumers. Food companies aim to reduce transaction costs by using global vertical integration and sourcing in their manufacturing processes. Through trade liberalization, investments in the food market, and the deregulation of markets, the global trade in and movement of food has increased tremendously (Hawkes et al., 2009).

Between 1972 and 2021, the global food trade grew from 224 billion US Dollars (Baker et al., 2020) to 1.7 trillion US dollars (UNCTAD, 2024), which is an increase of nearly 660%. In contrast, during the same time, the world population only grew by 104% (Ritchie et al., 2023). Food currently represents about 8% of the total global trade, which is an increase of two percentage points from 2000 (UNCTAD, 2024).

The change in global sugar consumption is, of course, also noticeable in the trade and production of raw sugar. Between 1961 and 2014, sugar production expanded from 53,2 to 176,9 million tons per year (Baker et al., 2020).

Transnational food producers, manufacturers, retailers, and fast-food chains have many incentives to expand their trade network and enter new markets. These include the opportunity for large profits and capitalization, the saturation of already established markets, and the knowledge capital needed to establish successful businesses abroad. Thus, they can shape the price, nutritional quality, availability and consumption of food in newly acquired local food markets (Pingali, 2007). Consequently, increased trade has driven down the price of sugar, contributing to the increased availability of sugar-sweetened products, including beverages, for consumers (Baker et al., 2020).

4.a.ii Technology

Secondly, advances in processing and production technology have made processed food products hyper-palatable and vastly increased their transportability and durability. Innovations in the speed of long-distance transport, combined with prolonged shelf life, have made it possible to sell processed food products even in remote markets (Baker et al., 2020).

Through newfound manufacturing and packaging techniques, the organoleptic qualities of processed products were improved. Factors like aroma, taste, flavour, structure and mouth feel have been optimized for consumption. Further, these innovations made it possible to globalize products, in other words to adapt global products to specific markets (Baker et al., 2020). This specific development will be discussed using the example of Coca Cola, Fanta Orange and Sprite later on.

4.a.iii Foreign Direct Investment

The third factor shaping the changes in the food system underpinning the nutrition transition is foreign direct investment (FDI). FDI is a long-term investment in another country through which a foreign affiliate becomes part of a parent company. Ever since 1990, foreign direct investments in developing countries have grown immensely. Last year, UNCTAD reported that FDI had reached an approximate 27-fold growth compared to 1990 (UNCTAD, 2023).

As described before, the regulatory environment for FDI has become more liberal in recent decades. Through the abolishment of investment barriers, paired with more incentives to invest abroad, transnational companies were able to gain an economic foothold in a multitude of countries. Starting with a huge wave of investments in the raw commodity export sector,

FDI soon shifted to the sale of processed foods in new host markets. This led to a dominance of foreign investors in the sector of highly processed food and drink production (Hawkes et al., 2009). At its highest, global FDI inflows for the primary agriculture industry accounted for 11.6 billion US Dollars, whilst FDI in the food processing industry reached 53 billion US Dollars in the same year (OECD, 2020). By 2015, food and beverage manufacturing accounted for approximately one percent of the world GDP, or about 750 billion US Dollars (OECD, 2021).

Especially in low- and middle-income countries foreign direct investment from transnational food companies has been a key mechanism in the nutrition transition. Since the 1980s, foreign direct investment into highly processed foods in new markets has enabled these companies to secure a strong market power in developing economies. This has significantly shaped global food markets and enabled the consumption of highly processed foods (Hawkes et al., 2009). FDI not only makes processed foods more accessible and available to a large part of the world's population but also enables advertising and marketing (Hawkes, 2006).

4.a.iv Advertisement

Finally, according to the Food and Agriculture Organization of the United Nations (FAO), diets adapt through increased consumption of highly processed branded food, caused by increased advertisement (Bruinsma, 2017). International processed food and beverage brands have increasingly utilized marketing to brand their product and target segments of local markets, differentiated by income, lifestyle, age, cultural preference and location (Hawkes et al., 2009). The effectiveness of food marketing has been proven through a multitude of studies and has turned into a multimillion-dollar industry in the last decades. Between 1980 and 2023, global spending on advertising rose from 216 billion (Hastings, McDermott, Angus, Stead, Thomson, & World Health Organization, 2007) to 889 billion U.S. dollars per year (Graham, 2023).

Some researchers claim this has contributed to the nutrition transition by making processed, branded food more desirable than traditional and less processed food. The capacity to adapt the global brand identity and product to the local context makes transnational food traders especially successful foods (Baker et al., 2020; Bruinsma, 2017). Hawkes found that marketing operations are thus mainly concentrated on lower and middle-income countries (Hawkes et al., 2009).

In particular, the diet behaviour of young people in developing countries is affected by perceptions of popular foods (Hawkes et al., 2009). Analyses of food marketing in Western countries have also found that advertisements disproportionately target young people (Kelly et al., 2010).

Other studies have shown that particularly sugar-heavy drinks are marketed aggressively, which influences consumption choices considerably (Boom et al., 2015). The Coca Cola company intensively utilizes social media, film, and television franchising to target audiences. In 2018 the Coca Cola Company reportedly spent 4.1 billion US Dollars in advertising globally, which accounts for about 13% of their net operating revenue (The Coca Cola Company, 2019).

4.b Social System Changes

Naturally, the rise in the international movement of raw materials, finance, production capacity, finance and technologies also substantially influences the social systems in which the consumption of food is embedded (Hawkes et al., 2009). Several studies have found that, with increasing income levels in the country and increasing urbanisation, more calories are consumed from processed foods, protein, sweeteners and fats (Baker et al., 2020). Economic changes caused by liberalization and urbanisation, such as per capita income growth and workforce and demographic shifts, make it possible for highly processed foods to enter new markets. With growing income, households can spend relatively more money on comparatively more expensive processed food. Additionally, the affordability of items which facilitate access to processed foods, such as refrigerators or microwaves, is affected by the same overall trends (Popkin, 2017). Simultaneously, physical activity patterns have changed over the past decades (Popkin & Ng, 2022). According to the FAO, these changes in consumer behaviour and attitudes are highly influenced by factors such as physical activity patterns, food culture, and the availability of processed foods through supermarkets (Bruinsma, 2017).

4.b.i Food Culture

A major social shift in the nutrition transition is the change in underlying eating behaviours. This pertains to how food is prepared as well as to how humans eat.

According to a study by Zhai et al., throughout the economic development of a country cooking methods like (stir-)frying and grilling are increasingly replacing steaming, boiling, baking, cooking or eating ingredients raw (Zhai et al., 2014).

Furthermore, with the economic development of a society, women increasingly partake equally in the labour market, making many households dual-worker households. This, in turn, reduces the available time for the preparation of meals and prompts a diet change towards more ready-made, often highly processed food. Food made outside of the home, as well as convenience food, saves time and opportunity costs, which are higher in households with two employed partners (Baker et al., 2020). A US study showed that the average time households

spent on meal preparation declined in the last 50 years from approximately 2 hours a day to 30 minutes (Popkin, 2004). A Chinese study from 2011 showed that children in large cities were already consuming 28% of their daily calories from packaged food (Zhai et al., 2014).

Additionally, nutrition scientists have noticed a shift in eating patterns (Duffey et al., 2013; Piernas & Popkin, 2010a, 2010b; Zhai et al., 2014). Instead of three major meals, individuals increasingly consume several smaller snacks in between meals, which increases the consumed calories considerably. This snacking density especially shifts upwards through the consumption of high-caloric beverages, such as sugar-sweetened beverages (Zhai et al., 2014). In low-income countries, barely any of the daily consumed calories stem from snacking (Du et al., 2014; Popkin, 2004; Zhai et al., 2014), whilst in some high-income countries, snacking can account for 20-25% of the daily calorie consumption (Duffey et al., 2013).

4.b.ii Physical Activity Patterns

Urbanisation decreases the distance to facilities where highly processed food products can be bought, for example supermarkets, whilst increasing the exposure to advertisements (Baker et al., 2020). With shorter distances and increased access to less strenuous modes of transportation, fewer calories are expended, and sedentary lifestyles are becoming more widespread. Transportation modes shift from overwhelmingly active, like walking or riding a bike, to passive. Additionally, cities are designed to encourage the use of vehicles. The change in mode of transportation alone has been found to double the likelihood of obesity in adults in China between 1993 and 2003 (Popkin, 2003).

Further, overall occupations have become less physical labour intensive. For example, between 1989 and 2006, it was found that the proportion of the Chinese population, in the age group from 10 to 45 years, which only performed light levels of activity increased from 24.7% to 40% (Popkin, 2004).

4.b.ii Supermarkets

Finally, another important vector of the nutrition transition is the retail sector's development, such as the spread and establishment of supermarket chains and larger convenience stores, which replace smaller independently owned and operated wet markets and stores.

In a typical case of trade liberalisation, multinational supermarket chains first establish branches in major cities and urbanized areas before spreading to more rural communities. These transnational food companies are often a highly lucrative vector of foreign direct investments. Local convenience stores or already established local supermarket chains are

purchased and integrated vertically into an existing transnational food enterprise network (Hawkes et al., 2009). Through this, foreign corporations take over the local food retail sector step by step (Baker et al., 2020).

It has been observed that, at first, supermarkets are mainly utilized as providers of processed and durable goods, whilst fresh produce and baked goods are still purchased at traditional smaller wet markets. With time, however, this changes, as, due to their market power, lower operating costs and economic efficiencies, supermarkets can offer products at a lower price. (Baker et al., 2020). For example, whilst in 1990, only about 15% of all food purchases in Latin America took place in supermarkets, over the next ten years, this grew exponentially to about 60% of all food purchases (Reardon & Berdegúé, 2002).

As wet markets or smaller stores cannot compete with the chain enterprises, they die out. A study from Mexico, for example, showed that with each opened supermarket five traditional stores went out of business (USDA Foreign Agricultural Service, 2006).

Furthermore, through supermarkets, transnational food processing companies are able to sell their products more efficiently by increasingly offering products which are specifically adapted to the local market. These companies do so by segmenting their product assortment and fine-tuning it to the specific market, by, for example, offering different taste variants of the same product. Supermarkets can more easily bear the risks connected with offering new products in their stores, as the relative financial risk of a new product failing is smaller than for smaller stores (Reardon & Berdegúé, 2002).

The increase in supermarkets and the decrease in traditional wet markets leads to a higher dependence on highly processed goods and a normalization of a wider array of available goods, which makes it even harder for smaller stores to compete (Hawkes et al., 2009). Supermarkets further introduce more ways to promote and sell their processed products, thus influencing the desirability of the food or drink item. A study from South Africa found that living in proximity to a supermarket or other processed food retailer significantly increased the likelihood of being overweight or obese (Otterbach et al., 2021).

In countries where large supermarket chains are not yet established, global food enterprises have found new ways to deliver their products and target more rural communities. One example for this is the sale of varying product sizes, according to the income of the region. In lower-income regions, the sold products are often smaller and thus more affordable. Another example is the exclusive sale in small traditional stores, which the Coca Cola Company employs in Mexico (Baker et al., 2020). These so-called *tiendas* are incentivized by the Coca Cola Company to exclusively sell its products through marketing schemes, like free refrigerators, point-of-sale material or other necessary sales equipment, in exchange for

exclusive sale rights. Utilizing this strategy, Coca Cola distributes its products to several thousand tiendas, which mostly operate in smaller, more rural and less affluent communities. Tiendas thus account for more than 90% of the yearly sales volume of Coca Cola in Mexico (Baker et al., 2020).

4.c Effects of and limitations to underlying system changes

To sum up, national advances in manufacturing technology, foreign direct investment and trade increase the entry of products, which are hyper-palatable and offer durability and transportability in the market of lower-income countries. In combination with high advertisement efforts of international brands, the local food culture is influenced, and a shift towards a “Western” diet is induced.

This shift is further aided by individuals' consumption and eating behaviours. These individuals, through the higher availability of products, higher disposable income for processed food, and less time for food preparation, consume a diet that includes more calories from processed foods, protein, sweeteners, and fats.

As already alluded to and addressed in more detail in the literature review section of this thesis, this nutrition transition can be seen clearly when it comes to sugar-sweetened beverages. Especially sugar-sweetened beverages have gained global popularity, as they offer a well-tasting, convenient and low-cost unit per calorie, compared to other nutrient-filled beverages, such as fruit juice or milk (Mchiza et al., 2016).

As mentioned before, it was also found that carbonated sugar-sweetened beverages were the most significant vector for increased sugar consumption in the nutrition transition occurring in Asia, irrespective of the observed countries income bracket (Baker & Friel, 2014). Over the last decades, sugar-sweetened beverages further have become more affordable, especially in low-income and middle-income countries, due to their economic growth (Blecher et al., 2017).

It has been observed that this change towards a “Western” diet takes place at increasingly earlier stages of the economic and social development of a country as well as at a greater speed than before. Global technological and economic advances are transforming local food chains and as global incomes are projected to increase, this effect will continue to influence global diets (Fanzo & Davis, 2021; Popkin, 2003; Popkin & Gordon-Larsen, 2004; Ranganathan et al., 2016).

This theory section cannot be ended without adding a caveat to this theory. Although analysis by the FAO has shown that through increasing integration in the world economy diets are converging in terms of commodities due to changes in income and price (Bruinsma, 2017),

according to some experts, these changes do not take place over the whole population equally (Baker et al., 2020; Popkin & Gordon-Larsen, 2004). The so-called dietary convergence-divergence theory describes that even though a number of food commodities are consumed increasingly globally, there is no such unitary development across the whole population within countries. Researchers have found differences within populations, such as cultural, demographic and socioeconomic factors, which shape food demand and consumption (Baker et al., 2020; Hawkes, 2006; Popkin & Gordon-Larsen, 2004).

For example, it was shown that within the US the consumption of sugar-sweetened beverages is not only differentiated between socioeconomic class, geography, age and sex, but also racial groups and ethnic sub-populations (Popkin, 2017). Furthermore, studies have shown that in high-income countries, Indigenous communities are still highly affected by the nutrition transition and thus experience its negative impacts particularly frequently, in contrast to richer socioeconomic classes, which mitigate the negative effects of this transformation (Bremer et al., 2011).

Other studies have shown that younger generations consume the most calories through sugar-sweetened beverages (Han et al., 2013). The consumption of these beverages varies substantially by age, or as some studies have found even follows a strict age gradient. Experts theorize that this higher consumption of sugar-sweetened beverages is a generational effect, as young people are particularly targeted and influenced by marketing for sugar-sweetened beverages (Kelly et al., 2010; US Federal Trade Commission, 2012; Singh, 2015).

These factors can unfortunately only be taken into account to a limited extent in this thesis, as the central variables of the following analyses, namely the sugar content in Coca Cola, Sprite and Fanta Orange, is only varied on a country level. In the research for this master thesis, no market in which more than one differing recipe of either of these three drinks was sold, was found.

This detailed theoretical exploration of the nutrition transition now provides the basis for the measured factors and included variables of the following statistical models. Here, some indicators of country internal differences in the nutrition transition are taken into account. This differentiation within countries will also be referred back to in the Discussion section of the paper.

5. Sub-Research Question 1

After covering the theoretical foundation of the nutrition transition, this section aims to determine whether a variable of “preference for sugar”, expressed through demand for sugar in a specific product, could conceivably be created. Several factors which increase the affordability and availability of sugar have been shown to have a significant impact on the overall consumption of sugar-sweetened products. However, it remains to be examined whether citizens from countries in different stages of economic development prefer sweeter or less sweet products. A variable expressing this preference would increase the explanatory power of nutrition transition research. Further, it could help to create more targeted and effective policies to curb the overconsumption of sugar.

To estimate this demand for sugar in a specific product, the sugar content of Coca Cola, Fanta Orange and Sprite is utilized. The sub-research question, which is thus addressed reads as follows:

“In how far is the sugar content in Coca Cola, Sprite and Fanta Orange a good indicator for the national demand for sugar or sugar preference?”

The question is posed to test the hypothesis that the sugar content of Coca Cola, Sprite and Fanta Orange are good indicators of the preference of the local population for sugar content in products. These products were selected as they are marketed globally but produced locally and changed to fit the local market characteristics, thus following a “glocalisation” strategy,

First, a theoretical explanation of why this master thesis hypothesizes that these variables are well-suited as indicators is given. In the second step, the data sourcing will be discussed in more detail. Finally, a statistical analysis will be conducted. The results will be discussed briefly at the end of this chapter and in more detail in the Discussion section.

5.a Utilized Variables

In this part of the thesis, it is argued that the sugar content of Coca Cola, Sprite and Fanta Orange are, from a theoretical point of view suitable variables to indicate the local sugar demand per product. This is used as a proxy variable for sugar preference in this thesis. Coca Cola, Fanta Orange and Sprite serve as very valuable variables in this Master Thesis mainly due to their global availability and regionally adapted recipes.

5.a.i Global Availability

Coca Cola, Fanta Orange and Sprite are global brands, which are sold in nearly every country of the world (excluding North Korea, Russia and Cuba) (The Coca Cola Company, 2024). The

Coca Cola Company claims to be active in 200 regions worldwide, with over 200 different brands ranging from carbonated beverages to juices, value-added dairy, water and sports drinks. With over 700.000 system associates worldwide, around 200 bottling partners and approximately 950 bottling plants Coca Cola is able to service the over 30 million retail customer outlets its products are currently sold at (The Coca Cola Company, 2024).

The Coca Cola Company is, with a global market share of about 25.8%, the international market leader in the carbonated soft drink industry. The company currently has double the market share of its closest competitor (Tagesschau, 2018). The enterprise controls 45.6% of the global carbonated beverages market (Baker et al., 2020). The Coca Cola drink and its sub-brands (like Coca Cola Zero) alone account for 32.8% of the global market for sugar-sweetened beverages (Blecher et al., 2017).

Starting in the 1980s Coca Cola expanded its global influence considerably by investing heavily in manufacturing plants and acquiring domestic competitors in new countries. This was for example, the case in 1993, when the Coca Cola Company acquired Parle Products in India, or the Lindley Corporation in 1999 in Peru (Baker et al., 2020). This has enabled Coca Cola to take up an oligopolistic market position in many countries (Tagesschau, 2018).

5.a.ii Regionally Adapted Recipes

Coca Cola adapts its products regionally. Regional franchisers bottle the beverages of the Coca Cola Company with recipes fitted to the market-specific demands and preferences (Macharzina, 2001; The Coca Cola Company, 2024). It is hypothesised that the variable is suitable to represent the local demand for sugar content in a product, as Coca Cola develops, manufactures and markets their beverage concentration syrups to bottling partners, which then finish and package these to sell to local customers and consumers. Most of these bottling companies and manufacturing plants are not owned by the Coca Cola Company, however the filling processes are strictly controlled by the corporation to upkeep quality standards (The Coca Cola Company, 2024).

The three discussed Coca Cola brands, in particular, can be seen as an ideal fit for this analysis, as the Coca Cola company utilizes a strategy to fit this product to the local market, which has been coined “glocal” (Tian, 2006). Glocal is a term to describe a product design process in which globally available products are tailored to a local market through changing certain characteristics of the product and its branding to fit the local audience, local culture and the local conditions better (Hawkes, 2006).

According to the theory of globalization, coined by Roland Robertson, the local and the global spheres do not lie on opposite sides of a spectrum but are mutually implicative. By dis-embedding and re-embedding brands in different contexts, consumers are introduced to

global contexts and become part of an international commodity network. The commonly known and often cited motto of “Think globally, act locally”, which Coca Cola also uses in internal communication, has its origin in Roland Robertsons’ theories (Foster, 2008).

Coca-Cola's glocal strategy was introduced in 2000 under CEO Douglas Daft. The strategy rests heavily upon the local bottling of the beverages produced. With a decentralized, instead of a vertically integrated bottling system, the company is able to not only have differing brands per market but also fit the products exactly to the preferences of the existing market (Foster, 2008).

After the Cold War Coca Cola was successful in rebranding its products from a symbol of American capitalism and cultural imperialism into a local product (Foster, 2008). The Coca Cola Company was able to do so by rooting its operations locally, penetrating local markets ideologically and economically, by seemingly increasing its brand authenticity and heterogeneity through launching locally centred hybrid products or re-launching of local and national culturally traditional drinks. By utilising the strategy of centralised franchising, the company has changed its strategy from the original standardized formula and globally standardised marketing. With centralised franchising, the Coca Cola Company retains strong control over franchised bottling operations while at the same time strengthening its multi-local approach (Crisanti, 2021).

This mixture of global and local describes Coca Cola’s worldwide brand presence, which is highly specified and fits the specific market in which Coca Cola is sold (Tian, 2006). This can be seen, for example, in these three examples in Figure 3 from Coca Cola China. The font of the logo is instantly recognizable as fitting the brand identity, the names are however written in Chinese characters. The logos of Coca Cola, Fanta Orange and Sprite do not differ in different countries, even when native scripts are used in the logo (The Coca Cola Company China, 2024).

Another prime example of this is the Fanta beverage. Whilst this study only takes data for Fanta Orange into account, the Coca Cola Company has developed over 70 different brands of Fanta, which are available at different times in different countries (Coca Cola, 2024). Further, the name Fanta is not used uniformly in every country, in the Dominican Republic for example, Fanta is called

Figure 3
Chinese Fanta Orange, Sprite and Coca Cola Design



Note. Pictures sourced from Coca Cola Company China, 2024

Country
Cola DO,
in
it is called
(Coca Cola
2024). The
identity,
remains consistent. This can be seen in Figure 4.



Club (Coca
2024), or
Myanmar
MAX+
MM,
brand
however,

As will be obvious from the analysis of the sugar content, the recipe for Fanta Orange differs immensely in different countries. However, when Fanta went through its last big rebranding in 2023, this was done on a global scale. After the font and logo of Fanta were renewed, the senior director of design of the Coca Cola Company, Sue Murphy, emphasized that: “Fanta’s identity, and particularly the logo, has evolved significantly from the 1940s to today. With this refresh, we aimed to crystallise each element of the brand to be bold and iconic so that we could ensure it would stand the test of time and be recognised around the world.” (Qureshi, 2023, p. 11).

5.b Data Source

Sugar Content Coca Cola, Sprite, Fanta Orange

The main individual scientific contribution of this thesis is the collection of sugar content per sugar-sweetened beverage per country. This variable is a highly innovative one, as it has not been used in any peer-reviewed publication so far.

Data about the sugar content of Coca Cola, Fanta Orange and Sprite is widely and freely available through the various websites of Coca Cola bottlers. For this analysis, the official country list of UNO-recognized countries was taken as a research base. In a first step, the nutritional information of the beverages in as many of the investigated countries as possible was collected by gathering data available on the internet. For this, the website of the Coca

Cola Company, as well as many of its bottling companies were scanned for current information. The websites of those bottling companies were identified through internet research. In many cases, national bottling companies did not share nutritional information openly on their websites. The author subsequently contacted these companies and asked them to provide further information.

In cases in which sugar content was provided in units other than 100ml, the corresponding sugar amount in grams per 100ml was calculated and rounded to two decimals. During the preliminary data collection for the sugar content of the three soft drink brands, it was found that most of the recipes date from 2022.

Overall, 359 data points were found. Of these 120 data points were found for Coca Cola, 118 for Fanta Orange and 121 for Sprite.

Sugar is the predominant sweetener used in Coca Cola, however in this study the term “sugar” will also be utilised for other caloric sweeteners, which are used by the Coca Cola company, such as molasses, high-fructose corn syrup, sweetening substances made from cereals, sugar crops, fructose, any types of mono- (glucose and fructose) and disaccharides (saccharose and sucrose), syrups, caramels, maple sugar, honey, glucose, maltose, dextrose, lactose, and other types of sugar confectionery (Popkin & Gordon-Larsen, 2004). Due to the technical limitations of this master thesis, there is no way for the author to check which sugars are utilized in which capacity in the observed Coca Cola, Fanta Orange and Sprite products. Therefore, for the purpose of this thesis, whatever the Coca Cola Company decides to label as sugar in the nutritional information of their products will be used as an indicator for the total sugar content. This will be discussed in more detail in the limitations section of this study.

Sugar Consumption per Capita

These variables are compared to the average sugar consumption per country. The data utilized to indicate the sugar consumption in a country is standardized food balance data provided by the Food and Agriculture Organization of the United Nations (FAO, 2023). Sugar consumption is often measured through different data sources, such as individual dietary surveys, household budget surveys or food balance sheets. In this study food balance sheets are utilised, as they are more accurate than other sources and are easily and readily available for most countries worldwide. These food balance sheets are accumulated by the FAO from national reports and indicate any imported food plus nationally produced food minus exported food on a country level whilst also discounting any food not used for human consumption (e.g. animal feed). This amount is presented per capita. Through this, a standardized quantity of food is formed for the average citizen of a country.

Unfortunately, this data does not give any indication of differences in consumption within the country, such as differences caused by socioeconomic distribution, geographical location, seasonal or temporal consumption differences within a year or environmental differences. Further, the data does not describe actual individual consumption, but only the availability of the food, which, according to some studies, often leads to a slight overestimation of consumed sugar (Kearney, 2010). These data limitations can unfortunately not be circumvented and have to be kept in mind when interpreting the trends resulting from the statistical modelling. Cross-sectional surveys, which would take individual consumption and characteristics into account, are not a viable alternative, as they are not conducted in many countries. Especially cross-sectional survey data for low-income countries is lacking, as these surveys are highly cost intensive and require both extensive labour and expertise. Even though surveys, which are conducted on an individual level, have the potential to explain intra-country differences more precisely, they have data deficiencies in the segment of less developed countries, therefore the FAO data is utilized in this study (FAO, 2023).

Country Income Groups

Finally, the World Bank's classification of countries into income groups is used in this thesis. This classification is renewed each year through calculations, which focus on the GNI per capita of the previous year. This classification is measured in US dollars, in accordance with the Atlas method, which has been utilized in this way since 1989 (World Bank, 2024d). To make the data as comparable as possible, the classification from the year 2022 is used in this Master Thesis, as this is the year most recipes from the free investigated sugar-sweetened beverages were published. The exact distribution of income groups can be found in Table 1 below.

Table 1

Country Income Groups according to World Bank

GNI per capita in US\$ (Atlas methodology)	
<i>Low-income (L)</i>	$\leq 1,135$
<i>Lower middle-income (LM)</i>	1,136 - 4,465
<i>Upper middle-income (UM)</i>	4,466 - 13,845
<i>High-income (H)</i>	$> 13,845$

Note. Sourced from World Bank, 2024d.

5.c Method

To determine whether the sugar content in locally accorded drinks is a good indicator of local sugar demand and thus local sugar preference, this analysis has four goals. In a first step, the data for the variables will be aggregated and explored. Secondly, it will be determined that these three variables have consistent effects between each other, and thirdly, that these variables are not just another expression of sugar consumption. Finally, the predictions of the theory of the nutrition transition will be compared to the insights generated from these variables. To reach these objectives, the following steps of analysis are going to be conducted:

First, it is imperative to rule out that the average sugar content in the sugar-sweetened beverage brands is directly proportional to the average sugar consumption in a given country. This has to be ruled out to ensure that these variables are not collinear, as this would weaken the argument that a separate effect from overall sugar consumption is being discussed. Therefore, the average sugar content of the sugar-sweetened beverage per country income group will be compared to the average sugar content consumed per country income group, according to FAO data. This is also an opportunity to learn more about the variable itself.

Secondly, it is going to be explored whether any regional patterns can be detected in the average sugar content per observed sugar-sweetened beverage. This is relevant, because, as shown in the literature review, sugar consumption is particularly high in some regions of the world, irrespective of the economic developments. This is the case, for example, in Latin America (Malik & Hu, 2022), the Caribbean, and Southeast Asia (G. M. Singh, Micha, Khatibzadeh, Lim, et al., 2015), or low like it is the case in Europe, North America and Australasia (Popkin & Hawkes, 2016). Therefore, this analysis is another way to determine, whether the sugar content per product is different from the average sugar consumption and another opportunity to get to know the three central variables better.

Third, a regression analysis between the average sugar consumption per country, as calculated by the FAO, and the observed sugar content per country will be employed to definitively reveal any correlation between the amount of sugar in these beverages and the nationally consumed sugar.

Fourth, it will be examined whether the three sugar content variables have a unified effect. If that is the case, the sugar content of the three investigated brands should be consistent per country. So, if in country A the sugar content is relatively high/low in one sugar-sweetened beverage compared to the average sweetness of this beverage, it should also be relatively high/low in the other two sugar-sweetened beverages compared to their respective average sugar contents. A Spearman correlation test is utilized to measure the monotonicity of the

relationship between the three variables. The Spearman rank correlation is chosen because this test, in contrast to a Pearson test, can be used for nonnormally distributed continuous data, and is robust to outliers.

Although these four steps of analysis will not be able to definitively prove the utility of these variables as a proxy for national sugar demand in a singular product, they will already serve as good indicators of a fit of variable, which will be discussed in detail in the Discussion section.

5.d Results

5.d.i Analytical Step 1

In this first step, the variables of sugar content of Coca Cola, Fanta Orange, Sprite and of Sugar Food supply quantity per kg per capita per year will be compared utilising the categorisation of low-, lower middle-, upper middle- and high-income countries, as illustrated by Table 2. The objective of this comparison is to establish whether the three sugar-sweetened beverage variables are simply a function of overall sugar consumption or if they have a distinctive effect. They are compared utilising the country income classes, as defined by the World Bank, to make it possible to compare them to predictions about the data made in the nutrition theory.

Table 2

Overview of surveyed variables

Variable	Definition	N	Mean	S.D.	Minimum	Maximum
<i>Coca Cola</i>	Sugar content in grams per 100ml	120	10,63	0,70	5	11,66
<i>Sprite</i>	Sugar content in grams per 100ml	121	6,93	3,56	0	12
<i>Fanta Orange</i>	Sugar content in gram per 100ml	118	8,5	2,99	4,4	14,5
<i>Sugar</i>	Sugar Food supply quantity (kg/capita/year)	182	24,25	24,86	2,23	52,39

Note. The variables Coca Cola, Sprite and Fanta Orange stem from the author’s research, the Sugar variable stems from FAO, 2024.

5.d.i.1 Coca Cola

120 observations of the sugar content in Coca Cola were found. These range from 5g of sugar per 100ml to 11,66g per 100ml. The median is 10,6g. The mean sugar content in Coca Cola is 10,63g per 100ml, with a standard deviation of 0,70g. In fact, in 68 of the 120 observations, Coca Cola has a sugar content of 10,6g per 100ml, making it the most consistent brand by far in terms of the sugar content of the three investigated sugar-sweetened beverages.

Furthermore, the Coca Cola with a sugar content of 5g, stemming from Egypt, is a stark outlier, with the next lowest value being 7,5 g of sugar per 100ml in Mexico.

For Coca Cola the sugar content of 49 high-income countries was observed. These have a sugar content between 9 grams and 11,3 grams per 100ml. The mean sugar content of Coca Cola in high-income countries is 10,67 grams, the median is 10,6 grams, and the standard deviation is 0,32g.

In the 34 observed upper middle-income countries the amount of sugar in Coca Cola ranges from 7,5 to 11,2 grams. Thus, the mean of this group is 10,59g, and the median 10,6g, with a standard deviation of 0.76g.

In lower middle-income countries, the sugar content of the 29 included observations ranges from 5 grams to 11,67 grams, with a mean of 10,57g, a median of 10,6g and a standard deviation of 1,1 grams, making it the most dissimilar group of countries in terms of Coca Cola sugar content.

Unfortunately, only seven observations of the sugar content in Coca Cola in low-income countries could be found, these ranged from 10.6 to 11 grams, with a median of 10.7g and a mean of 10.79g. The standard deviation of this group is 0.2g.

Thus, for this brand, the highest mean sugar content could be found in low-income countries, followed by high-income countries, upper middle-income countries and subsequently lower middle-income countries.

5.d.i.2 Fanta Orange

Overall, 118 observations of the sugar content of Fanta Orange were made. These sugar-sweetened beverages have between 4,4 grams and 14,5 grams of sugar per 100ml. The mean of all observed Fanta Oranges thus is 8,5g, and the median 7,8g, with a standard deviation of 2,99 grams.

In high-income countries, there were 49 observations of Fanta Orange. The sugar content in high-income countries ranged from 4,5g to 14,5g with a mean of 8,42g, a median of 7,7g and a standard deviation of 3,18 grams per 100ml.

In upper-middle-income countries 33 observations could be made. Fanta Orange has between 4,6g and 14g of sugar per 100ml. Here, the mean is higher at 8,56g, the median is set at 9g, and the standard deviation is 2,59g per 100ml.

In low-middle-income countries the sugar content of Fanta Orange in the 28 included observations ranges from 4,4g sugar per 100ml to 13,7g per 100ml. The mean in this category is 8,33g, the median is 7,75g per 100ml, and the standard deviation is 3,08g.

Unfortunately, only seven observations of sugar content of Fanta Orange could be found in low-income countries. These range from 5,7g to 13g, with a mean of 9,07g per 100ml and a median of 8,9g. The standard deviation of this sample is 3,44g, making it the most diverse observed group of countries.

In this case, low-income countries again have the highest average sugar content, followed by upper middle-income countries followed by high-income countries and lower middle-income countries.

5.d.i.3 Sprite

The sugar content of Sprite in 121 countries was collected and this ranges from 0g of sugar to 12g per 100ml. The mean Sprite worldwide has 6,93g of sugar per 100ml, the median sugar content of the observed beverages is 7,9g, with a standard deviation of 3,56g.

The amount of sugar per 100ml in 49 high-income countries could be observed. The sugar content ranges from 0g to 11,8 grams of sugar per 100ml of Sprite, while the mean of this sample is 7,48g, the median 7,9g, and the standard deviation 3,36g.

34 observations of Sprite's sugar content in upper middle-income countries were made. These drinks have a sugar content ranging from 0 grams to 12 grams. The mean sugar content of Sprite in upper middle-income countries is 6,35g, the median 4,95g, and the standard deviation is 3,96g.

The nutritional data of sugar in Sprite could be found in 28 lower middle-income countries. The sugar content of these ranges from 3g to 11,7g per 100ml, with a mean of 6,59g, a median of 5,58g, and a standard deviation of 3,36g.

In low-income countries only nine observations of sugar content could be found. These range from a minimum of 3,1g sugar per 100ml to a maximum of 11,8 grams. The mean of this sample is 7,71g, the median 9g and the standard deviation 3,56g.

In the observed Sprite drinks low-income countries have the highest sugar content, followed by high-income countries, lower middle-income countries and subsequently upper middle-income countries.

5.d.i.4 Sugar Consumption

According to the nutrition theory, sugar, like other ingredients common in “Western” food, should be consumed very little in low-income countries, then increasingly more with economic development and plateau in high-income countries (Popkin, 2003). This theory is not directly portrayed in the available data. With an average sugar consumption per capita per country per year of 11,01kg in low-income countries, 19,81kg in lower middle-income countries, 28,83kg in upper middle-income countries and 30,49kg in high-income countries, the plateauing effect in high-income countries does not emerge. Although the difference between sugar consumption between low-income, lower middle-income and upper middle-income is significantly larger than between upper middle-income and high-income countries, the growth is nevertheless unexpected. This will be taken into account in the methods section of the Sub-Research Question 2 and will be discussed in more detail in the final discussion of this master thesis.

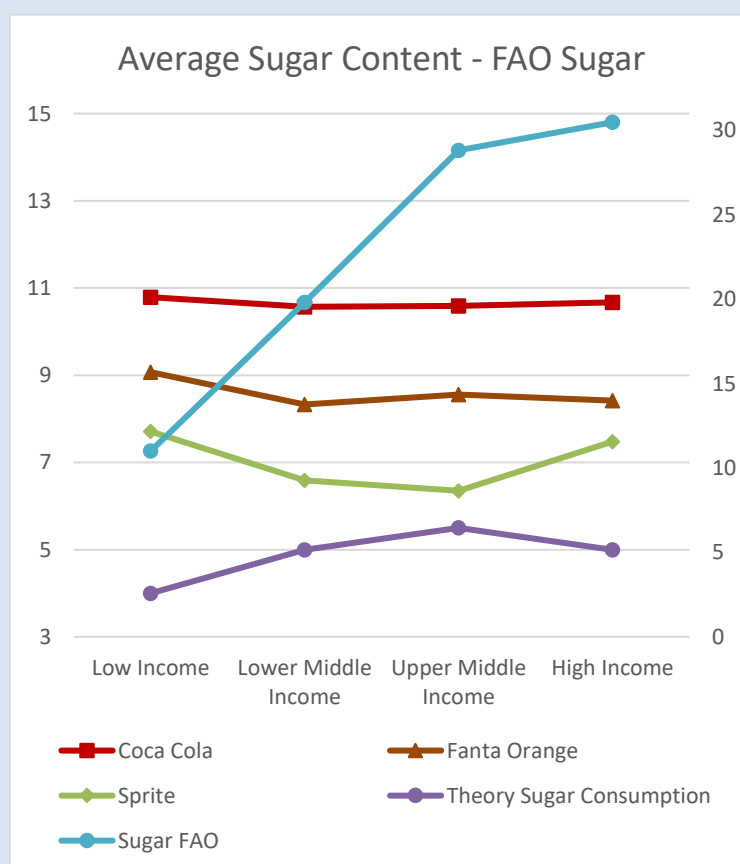
Overall, it can be seen, as summarized in Figure 5 that neither the sugar consumption, nor the sugar content per beverage fit the theorized distribution. Furthermore, the sugar contents per beverage clearly have a distinct distribution from sugar consumption. The three different sugar-sweetened beverages have highly different average sugar contents per country group.

5.d.ii Analytical Step 2

For the next analytical step, potential regional patterns in the average sugar content of the three discussed sugar-sweetened beverages will be observed and compared to the regional patterns of the already discussed FAO sugar variable. Again, this will help to understand the observed sugar content variables better and ensure that a variable

Figure 5

Comparison Average Sugar Content and Sugar Consumption



Note. The variables Coca Cola, Sprite and Fanta Orange stem from the author's research, the Sugar variable stems from FAO, 2024.

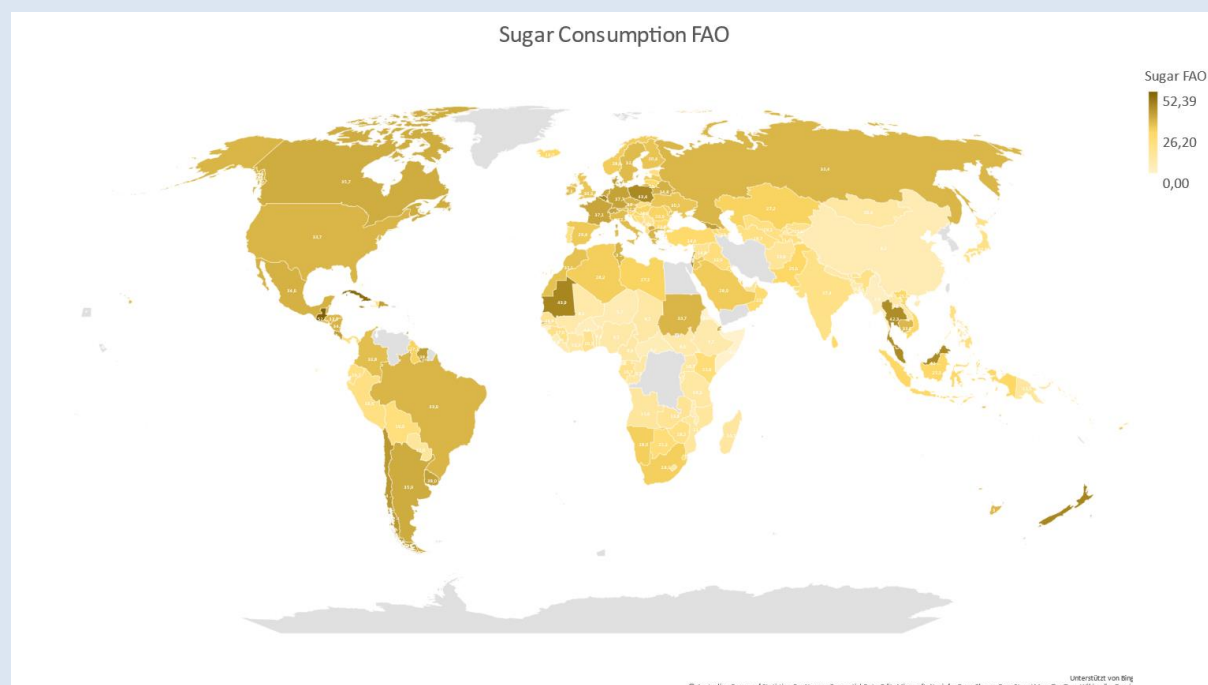
independent from overall sugar consumption is observed. Furthermore, by comparing the regional patterns of the three beverages, the internal validity of a potential variable for sugar preference in a comparable product can be tested. Several authors have found regional sugar consumption patterns, which tend to be especially high in Latin America, the Caribbean and Southeast Asia (Malik & Hu, 2022; G. M. Singh, Micha, Khatibzadeh, Lim, et al., 2015) and especially low in North America, Australasia and Europe (Popkin & Hawkes, 2016).

To visualise potential regional patterns, Figure 6 provides an overview of average sugar content and sugar consumption per country. Table 3 provides detailed results for each region and sub-region. These regions have been modelled after the UNSD geoscheme (UNSD, 2024).

5.d.ii.1 Sugar Consumption

Figure 6

Average Sugar Consumption per Country



Note. This map shows the average sugar consumption in kg per year, per capita, per country, with data sourced from the FAO, 2024.

Table 3

Average sugar consumption per region

Region	Subregion	Number of observations	Mean	Median	Standard Deviation
<i>Africa</i>		51	16,24	11,62	10,77
	Northern Africa	6	29,49	29,68	4,29
	Eastern Africa	16	14,79	11,13	9,05
	Middle Africa	9	10,31	9,89	4,66
	Southern Africa	5	21,57	21,24	7,62
	Western Africa	16	14,11	9,67	12,84
<i>Americas</i>		35	32,19	33,60	9,31
	Caribbean	13	33,81	37,03	9,79
	Central America	8	34,74	33,78	8,88
	South America	12	28,35	29,44	9,35
	Northern America	2	34,69	34,69	1,41
<i>Asia</i>		47	22,11	21,77	10,34
	Central Asia	5	19,88	18,70	4,29
	Eastern Asia	7	15,69	17,67	9,17
	South-eastern Asia	8	25,25	25,59	14,29
	Southern Asia	9	18,01	17,39	7,99
	Western Asia	17	26,71	24,62	9,30
<i>Europe</i>		39	29,36	30,14	7,73

Oceania	Eastern Europe	10	30,11	29,19	6,58
	Northern Europe	10	29,19	29,69	5,18
	Southern Europe	12	26,15	25,93	7,84
	Western Europe	7	34,04	37,41	10,67
		10	27,31	28,18	11,73
	Australia and New Zealand	2	38,63	38,63	7,87
	Melanesia	4	17,33	14,66	7,93
	Micronesia	3	33,04	35,76	10,82
	Polynesia	1	27,43	27,43	0

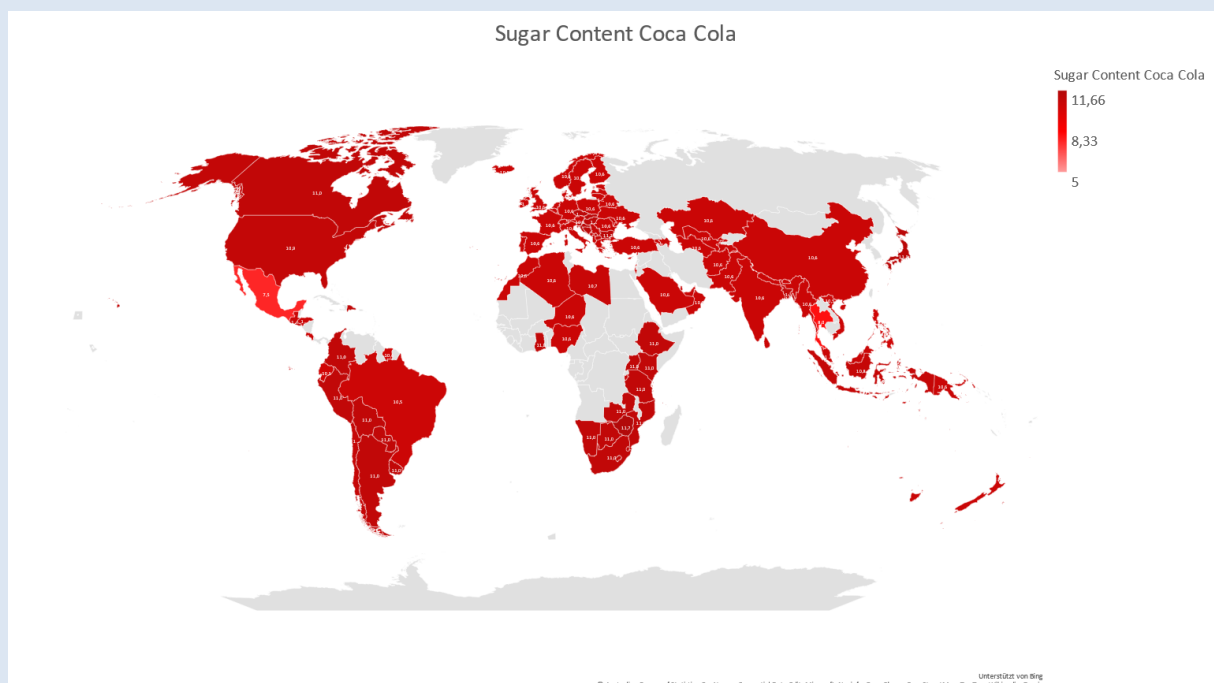
Note. This table shows the average sugar consumption per region and sub-region as defined by UNSD, using averages compiled from FAO 2024 data in kg, per capita, per year, per country.

In line with the cited literature, according to FAO data, the highest mean consumption of sugar per capita per country per year can be found in the Americas, especially in Central America and Northern America; Europe, especially Western and Eastern Africa; and in Oceania, especially Australia and New Zealand and Polynesia. The lowest average sugar consumption can be found in Africa, especially in Middle and Western America, which is also in line with the findings of researchers (Popkin & Hawkes, 2016).

5.d.ii.2 Coca Cola

Figure 7

Sugar Content in Coca Cola per Country



Note. This map shows the sugar content of Coca Cola in g per 100ml per country, data was collected by the author and can be found in the annex.

Table 4*Average sugar content of Coca Cola per region*

Region	Subregion	Number of observations	Mean	Median	Standard Deviation
<i>Africa</i>		21	10,64	11,00	1,31
	Northern Africa	4	9,23	10,60	2,81
	Eastern Africa	9	11,03	11,00	0,27
	Middle Africa	0			
	Southern Africa	5	11,00	11,00	0
	Western Africa	3	10,73	10,6	0,23
<i>Americas</i>		18	10,60	10,85	0,81
	Caribbean	1	11,00	11,00	0
	Central America	5	10,00	10,60	1,40
	South America	10	10,80	11,00	0,29
	Northern America	2	10,94	10,94	0,05
<i>Asia</i>		35	10,52	10,60	0,54
	Central Asia	4	10,60	10,60	0
	Eastern Asia	4	10,38	10,60	0,97
	South-eastern Asia	8	10,27	10,60	0,92
	Southern Asia	8	10,70	10,60	0,19
	Western Asia	11	10,61	10,60	0,03
<i>Europe</i>		43	10,72	10,60	1,51
	Eastern Europe	9	10,87	10,60	0,32
	Northern Europe	10	10,60	10,60	0
	Southern Europe	15	10,79	10,60	0.24
	Western Europe	9	10,6	10,6	0
<i>Oceania</i>		3	10,60	10,60	0
	Australia and New Zealand	2	10,60	10,60	0
	Melanesia	0	0	0	0
	Micronesia	1	10,60	10,60	0
	Polynesia	0	0	0	0

Note. This table shows the average sugar content of Coca Cola per region and sub-region as defined by UNSD, using averages compiled from data in g/100ml compiled by the author, these can be found in the annex.

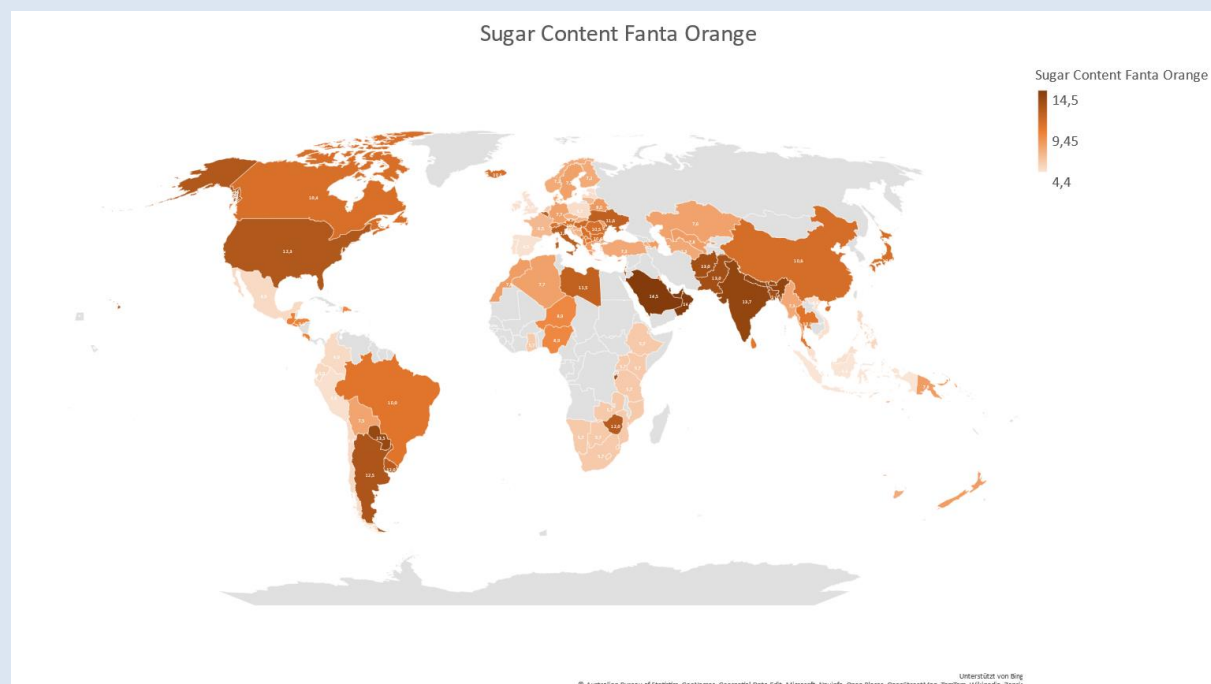
As discussed before, in more than half of the observed countries, the sugar content of Coca Cola is 10,6 grams, this can be seen in the graphic representation of Figure 7 as well as the average regional sugar content summarised in Table 4. Especially in the Americas, the average Coca Cola recipe is very consistent in terms of sugar content. Asian countries, especially South-eastern Asia, seem to have the lowest sugar content on average, and Europe, especially eastern Europe, the highest. This is partially in line with the average sugar consumption per country, where one of the highest consumption rates can also be found in Eastern Europe. Once again, these results vary very little, the most diverse region being Northern Africa. In three regions, namely Western Europe, Northern Europe and Southern Europe there is no

variation between the differing recipes. This can be explained by unified multinational bottling companies in these regions.

5.d.ii.3 Fanta Orange

Figure 8

Sugar Content in Fanta Orange per Country



Note. This map shows the sugar content of Fanta Orange in g per 100ml per country, data was collected by the author and can be found in the annex.

Table 5

Average sugar content of Fanta Orange per region

Region	Subregion	Number of observations	Mean	Median	Standard Deviation
Africa		21	7,12	5,70	2,38
	Northern Africa	4	8,18	7,75	2,42
	Eastern Africa	9	7,21	5,7	1,36
	Middle Africa	0			
	Southern Africa	5	5,70	5,70	0
Americas	Western Africa	3	7,83	8,90	1,85
		17	8,71	9,10	2,98
	Caribbean	1	9,00	9,00	0
	Central America	5	8,32	9,10	1,92
	South America	9	8,32	7,5	3,70
Asia	Northern America	2	11,35	11,35	1,34
		34	9,76	9,95	3,68
	Central Asia	3	7,57	7,60	0,25
	Eastern Asia	3	8,57	10,50	3,44

<i>Europe</i>	South-eastern Asia	8	5,64	4,60	2,00
	Southern Asia	8	13,00	13,35	1,31
	Western Asia	12	11,20	11,80	3,28
		43	8,16	7,70	2,39
	Eastern Europe	9	8,66	8,00	2,33
	Northern Europe	10	6,49	6,85	1,94
	Southern Europe	15	8,50	9,00	2,39
<i>Oceania</i>	Western Europe	9	8,96	10,30	2,38
		3	7,63	7,80	0,38
	Australia and New Zealand	2	7,55	7,55	0,49
	Melanesia	0	0	0	0
	Micronesia	1	7,80	7,80	0
	Polynesia	0	0	0	0

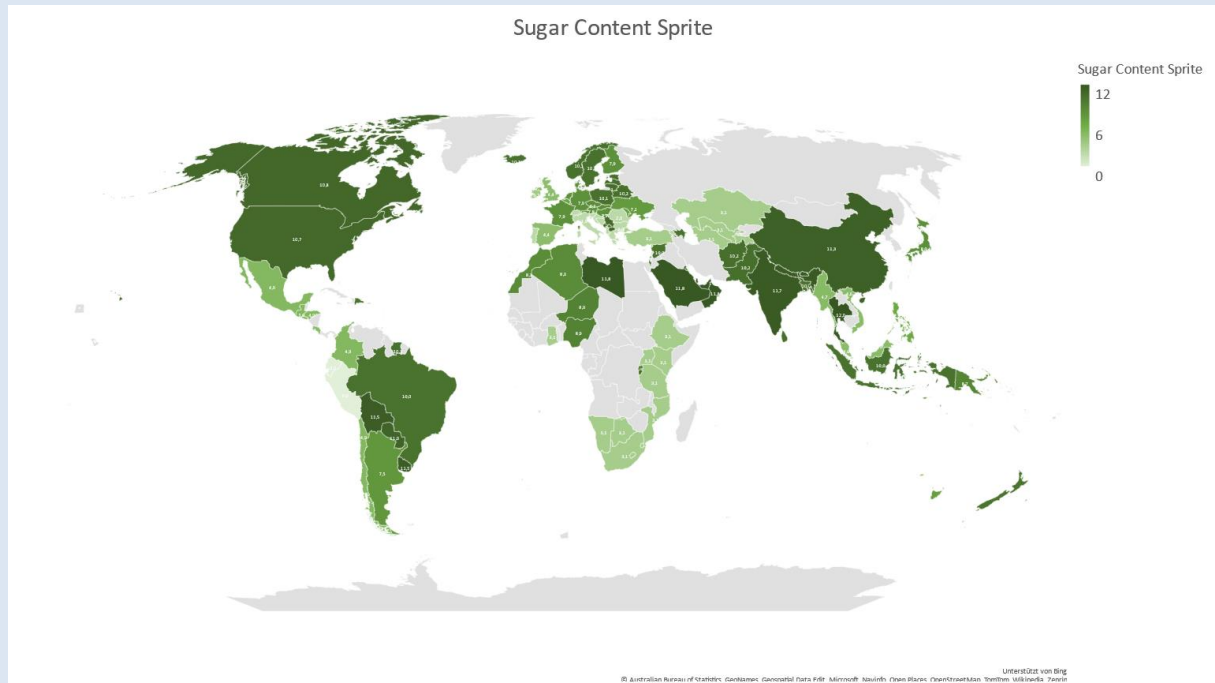
Note. This table shows the average sugar content of Fanta Orange per region and sub-region as defined by UNSD, using averages compiled from data in g/100ml compiled by the author, these can be found in the annex.

As can be seen in Figure 8 and Table 5, Fanta Orange's regional recipes vary more substantially than those of Coca Cola, with the highest continental group having a mean sugar content of 9,76g (Asia) per 100ml and the lowest just 7,12g (Africa). In the subregions, this difference is even more extreme, here the average sugar content of Fanta Orange varies between 5,7 in Southern Africa to 13g in Southern Asia. With a standard variation of 3,68g, Fanta Orange is also the most diverse in Asia, especially in Western Asia. In Oceania, however, the average sugar content of different regions is very similar. This is, of course, also caused by the relative data unavailability in Oceanian countries. The highest sugar content can be found in Asia, which is the exact opposite to Coca Cola, where Asia had on average the lowest sugar content. This result is surprising, as it is not in line with the data on sugar consumption by the FAO or any predictions made by the literature.

5.d.ii.4 Sprite

Figure 9

Sugar Content in Sprite per Country



Note. This map shows the sugar content of Sprite in g per 100ml per country, data was collected by the author and can be found in the annex.

Table 6

Average sugar content of Sprite per region

Region	Subregion	Number of observations	Mean	Median	Standard Deviation
Africa		21	5,18	3,10	3,09
	Northern Africa	4	7,85	8,30	3,63
	Eastern Africa	9	4,54	3,10	1,38
	Middle Africa	0			
	Southern Africa	5	3,10	3,10	0
	Western Africa	3	6,97	8,90	3,35
Americas		18	7,06	6,25	3,78
	Caribbean	1	10,00	10,00	0
	Central America	5	4,84	4,90	0,15
	South America	10	7,14	8,75	4,49
	Northern America	2	10,75	10,75	0,07
Asia		36	8,13	10,00	3,69
	Central Asia	4	3,10	3,10	0
	Eastern Asia	3	9,30	8,60	0,62
	South-eastern Asia	8	6,42	4,65	2,93
	Southern Asia	8	10,71	10,20	0,82
	Western Asia	13	8,88	10,00	4,23
Europe		43	6,61	7,90	3,38

<i>Oceania</i>	Eastern Europe	9	6,98	7,90	3,03
	Northern Europe	10	8,44	10,10	2,60
	Southern Europe	15	5,38	2,00	4,10
	Western Europe	9	6,27	7,80	2,53
		3	8,50	8,70	1,51
	Australia and New Zealand	2	8,40	8,40	2,12
	Melanesia	0	0	0	0
	Micronesia	1	8,70	8,70	0
	Polynesia	0	0	0	0

Note. This table shows the average sugar content of Fanta Orange per region and sub-region as defined by UNSD, using averages compiled from data in g/100ml compiled by the author, these can be found in the annex.

Of the three investigated sugar-sweetened beverage brands Sprite has by far the highest range between continents, as can be seen in Table 6 and Figure 9. With 5,18g per 100ml, the African Sprite has the least amount of sugar, with 8,50g Sprite in Oceania has the highest sugar content. Looking at sub-regions, Southern Africa has an especially low average sugar amount with 3,1g and Southern Asia (10,71g) and Northern America (10,75g) an especially high amount. This again shows a new pattern in comparison to Fanta Orange, Coca Cola, the average sugar consumption, and predictions made by the literature.

5.d.ii.5 Conclusion

The results from this analysis clearly indicate that the regional patterns of the average sugar content in these beverages are highly heterogeneous, as there is neither a clear pattern among sub-regions within one brand nor regions between different brands. Furthermore, the patterns that can be observed here do not bear any resemblance to the patterns of average sugar consumption per country or region. Further, the average regional sugar content per drink largely does not conform to observations made in the surveyed literature about sugar consumption.

There seems to be no direct connection between the regionality of sugar consumption and sugar content per beverage. In addition, this analysis indicates that there is little connection between the three sugar content variables.

5.d.iii. Analytical Step 3

To further rule out that the sugar content of these beverages is just a function of the sugar consumed per country and that the variables are thus colinear, the amount of sugar per 100ml in these three brands is regressed against the amount of sugar consumed per country. As the main hypothesis of this master thesis is that the total sugar consumption in a country depends on various factors such as income, price, or preference, there is no need to test for a reversed causality. A simple linear regression analysis of the sugar consumption data, provided by FAO, and the sugar content variables is done, following this formula.

$$Y_{\text{Sugar}} = \alpha_0 + \alpha_1 \text{Coca Cola} + \alpha_2 \text{Fanta Orange} + \alpha_3 \text{Sprite} + \varepsilon$$

Wherein Y_{Sugar} connotes the average amount of sugar consumed per capita per year per country, *Coca Cola*, *Fanta Orange*, and *Sprite* denote the sugar content per beverage, and ε an error term.

Table 7

Regression Results Sugar, Coca Cola, Fanta Orange, Sprite

Name	Coefficient	P-Value
<i>Coca Cola</i>	-1,751042	0,2265
<i>Fanta Orange</i>	-0,362500	0,3822
<i>Sprite</i>	0,449308	0,1943
	Probability F-Statistic	0,335056

Note. This table shows regression results based on sugar data (FAO, 2024) and data compiled by the author, sources for this can be found in the annex.

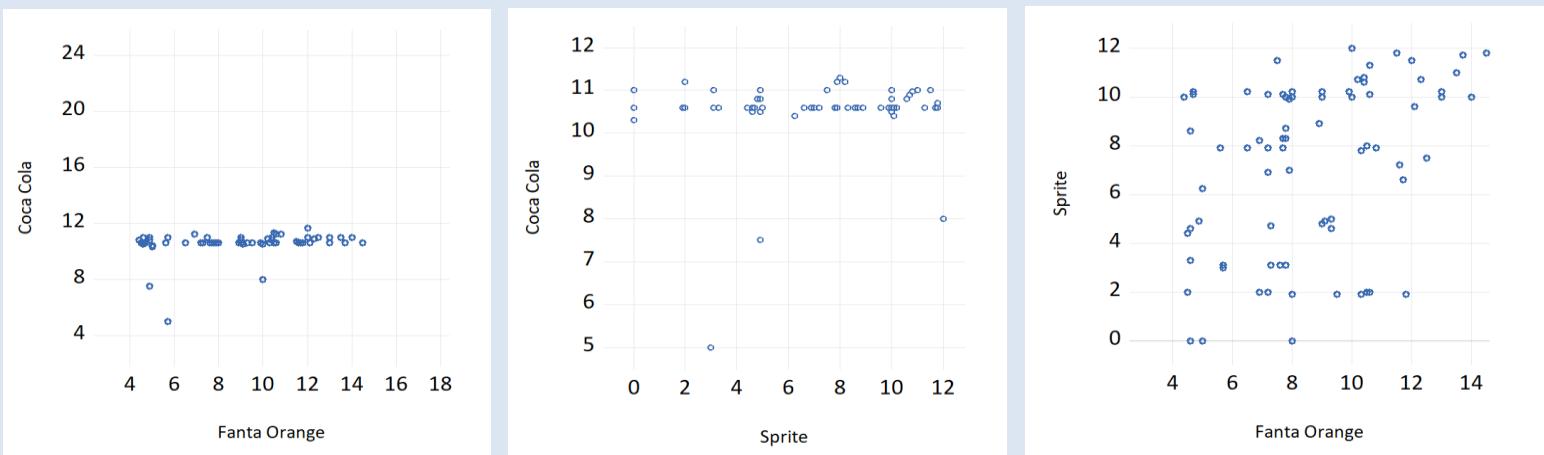
The results of this correlation clearly show through the probabilities of each variable as well as the probability of the F-statistic, that no statistically significant relation between the Coca Cola, Fanta Orange and Sprite sugar content variable and the average sugar consumption per country can be found.

5.d.iv Analytical Step 4

As explained above, to estimate whether the variables of Coca Cola, Fanta Orange and Sprite are consistent indicators of sugar preference in a comparable product, a Spearman Rank Correlation is used. For this analysis a monotonic relationship between the data is assumed. This is based on a visual inspection of scatterplots depicting the three variables, which can be seen in Figure 10.

Figure 10

Scatterplots of Coca Cola with Fanta Orange, Coca Cola with Sprite and Fanta Orange with Sprite



Note. The scatterplots are based on sugar content measured in g per 100ml, the source of this data can be found in the annex.

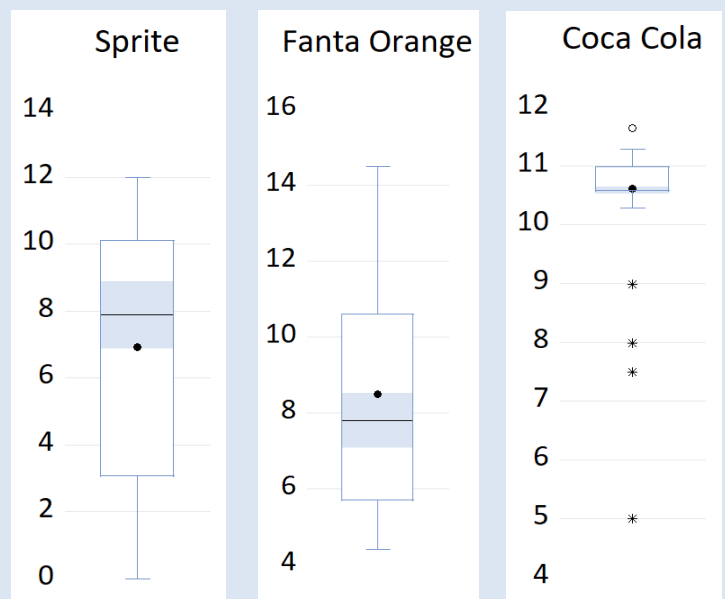
The scatterplots do not show any clear evidence of linearity or non-linearity, which is why the Spearman Rank Correlation is chosen over the Pearson correlation.

Next, it has to be assessed whether the three variables confirm the second assumption important in the choice of a correlation measure, the normality assumption. For this, boxplots of the data are inspected, these can be found in Figure 11. These boxplots do not seem consistent with a normal distribution, as the median of the data is in no case close to the centre of the box and both whiskers have different lengths at each variable.

Another way to check for normal distribution is to observe if the absolute value of the skewness coefficient of the variable should not exceed their standard errors times two.

Figure 11

Boxplots of Coca Cola, Fanta Orange, and Sprite



Note. The boxplots are based on sugar content measured in g per 100ml, the source of this data can be found in the annex.

According to Table 11 this is not the case.

Table 11

Basic Properties of Coca Cola, Sprite and Fanta Orange

Variable	N	Mean	Median	Minimum	Maximum	Skewness	Standard Error
<i>Coca Cola</i>	120	10,63	10,60	5	11,66	-5,54	0,70
<i>Sprite</i>	121	6,93	7,9	0	12	-0,21	3,56
<i>Fanta Orange</i>	118	8,5	7,8	4,4	14,5	0,41	2,99

Note. This table is based on sugar content measured in g per 100ml, the source of this data can be found in the annex.

In the case of Coca Cola, this is clearly not the case. In both other variables this condition is given. Therefore, it cannot be assumed that the data of Coca Cola is normally distributed, and a Spearman correlation analysis is employed.

Table 12

Spearman Rank Correlation Coefficient

Variable	Coca Cola	Sprite	Fanta Orange
<i>Coca Cola</i>	1,000		
<i>Sprite</i>	0,005266	1,000	
<i>Fanta Orange</i>	0,076593	0,529369***	1,000

Note. This table is based on sugar content measured in g per 100ml, the source of this data can be found in the annex. This regression was analysed using EViews as statistical software, and a $p < 0.1$ is statistically significant, smaller p-value signifies a better performance. Asterisks represent the following: “*” $0.05 < p < 0.1$, “**” $0.01 < p < 0.05$, and “***” $p < 0.01$.

As can be seen in the results, the Correlation Coefficient between Fanta Orange and Sprite is the only one of statistical significance. There is a moderate, positive monotonic correlation between Fanta Orange and Sprite.

This, however, means that the three variables are not very correlated, which makes it less likely that they accurately represent a consistent “demand/preference for sugar” effect.

5.e Preliminary Conclusion Research Question 1

This section set out to answer the research question: “In how far is the sugar content in Coca Cola, Sprite and Fanta Orange a good indicator for the national demand for sugar or sugar preference?”.

Although a theoretical explanation argued why Coca Cola, Fanta Orange and Sprite are globalized products, which could serve well in a global comparison of local sugar preference in a product, this was not supported by the empirical analysis of the available data. This analysis aimed to achieve four objectives: to get to know the variables in more detail, to determine that these three variables have consistent effects between each other, to show that these variables indicate an effect distinct from sugar consumption and to show the connections between the predictions of the theory of the nutrition transition and these variables.

First, the good: Statistical tests clearly showed that these variables do not correlate with average sugar consumption and thus would not cause collinearity with sugar consumption variables. This is a good indicator that these variables could be usable.

However, some particularities of the variables also came to light, which may cast doubts on the usability of these factors like the fact that Coca Cola has the same sugar content across 68 countries.

As this analysis clearly showed, Coca Cola, Fanta Orange, and Sprite's sugar data do not have similar regional patterns or patterns among country income groups. The observed sugar content variables do not show great cohesion with the discussed nutrition transition theory.

A Spearman Correlation Analysis showed that only Fanta Orange and Sprite are moderately monotonically correlated, so at the very least, it can be concluded that not all three factors accurately represent preference or demand for sugar.

To definitively prove whether Coca Cola, Sprite or Fanta Orange could be used as a proxy variable for taste or demand for sugar per product, they will be included in a model of the nutrition transition in the next step and their statistical significance will be tested.

6. Sub-Research Question 2

6.a Method

The main methodology of this master thesis is an econometric analysis of the sugar content in a comparable product, sugar consumption, and factors pertaining to economic development. By analysing the variable of sugar content in a comparable product in relation to the already established relation between sugar consumption and economic development it is tested in how far the sugar content of the product, as a proxy variable for preference for sugar, is a confounding variable in this relation and can therefore add to the current literature on the nutrition transition.

The sub-research question which will be answered here is: “In how far are these variables statistically significant factors in the relationship between the average national sugar consumption and economic development?”.

To do so, the established theory of the nutrition transition will be modelled statistically and the new variable of sugar content per 100ml will be added to the regression model. This will be a cross-country regression, including as many countries as possible in different stages of economic development. According to the nutrition transition theory, the stage in which a country is in this transition determines the composition of the average national diet. Thus, the average sugar consumption per capita will be the dependent variable in this equation.

The nutrition theory further posits that several factors, like the average national income, urbanization level of a country, affordability of processed foods, national presence of transnational food corporations, the existence of retailing chains and a change in consumer behaviour and attitudes are vectors of this transition (Kearney, 2010). Unfortunately, not all of these factors can be measured through globally available data. This particularly pertains to the national presence of transnational food corporations, the existence of retail chains, and the change in consumer behaviour and attitudes.

To establish a model which represents the nutrition transition as accurately as possible the following independent variables are used, drawing inspiration from Ferretti & Mariani (2019):

- Measures of economic development
 - Gross National Income per capita
- Measures of Globalization
 - KOF Globalization Index
- Social System Changes
 - Prevalence of overweight: Age-standardised rate

- Prevalence of obesity: Age-standardised rate
- Median age per country
- Gender Inequality Index
- Food System Changes
 - Urban population: Percentage of total population living in urban areas
 - Employment in services as percentage of total employment
 - FDI in food sector
- Possible direct influences on sugar consumption
 - Sugar-sweetened beverage tax dummy
 - Sugar content of Coca Cola, Fanta Orange, and Sprite in grams per 100ml
 - Sugar-sweetened beverage price
 - Sugar-sweetened beverage price relative to country income

The utilized variables and their sourcing will be discussed in more detail later in the paper. This data and its possible correlation will be investigated using the software EViews and R.

This study uses the conceptual framework of the nutrition transition to analyse the global consumption of sugar. As discussed before and backed up by literature in early stages of economic development sugar consumption is low due to associated costs and the adherence to traditional diets. Through economic development, the nutrition transition occurs, rapidly increasing the amount of consumed sugar. However, with higher economic development, through health consciousness and regulation, the amount of consumed sugar reaches a plateauing effect and stagnates or, according to some studies, even declines (Baker et al., 2020).

One might theorize that the relationship between economic development and sugar consumption thus may follow a “Sugar Kuznets curve”, coined by the environmental Kuznets curve. However, few empirical studies have thus far found evidence of such a strong relationship and have more found general evidence of higher sugar consumption in lower middle-income countries and upper middle-income countries than in low-income countries and high-income countries (G. M. Singh, Micha, Khatibzadeh, Lim, et al., 2015).

When observing the sugar data utilized by the FAO, as it was explored in Analytical Step 1, it becomes clear that there is no such clear “Kutznetz curve” between sugar and income in this data. Although the growth of the average sugar consumption decreases considerably in high-income countries, it is still on average higher than in upper-middle-income countries.

It is hypothesized that a model in which the variables of sugar content of Coca Cola, Fanta Orange and Sprite are included should have a higher explanatory power (so adjusted R²) than a model without these factors. This paper theorizes that the relationship between the average

national sugar consumption and the economic development of a country is, in line with the theory of the nutrition transition, mediated by this measure of demand for sugar in a product, and thus that statistically significant results can be found.

To explore this relationship, the following multivariate regression model, here named Model 1, is employed:

$$\begin{aligned}
 Y_{sugar} = & \alpha_0 + \alpha_1 Coca\ Cola + \alpha_2 Fanta\ Orange + \alpha_3 Sprite + \alpha_4 GDP + \alpha_5 KOFGI \\
 & + \alpha_6 Overweight + \alpha_7 Obesity + \alpha_8 Employment\ Service \\
 & + \alpha_9 Median\ Age + \alpha_{10} Sugar\ Tax\ Dummy + \alpha_{11} Sugar\ Tax\ Dummy \\
 & * Coca\ Cola + \alpha_{12} Sugar\ Tax\ Dummy * Fanta\ Orange \\
 & + \alpha_{13} Sugar\ Tax\ Dummy * Sprite + \alpha_{14} Urban\ Pop + \alpha_{15} Gender \\
 & + \alpha_{16} FDI + \alpha_{17} Price + \alpha_{18} Affordability + \varepsilon
 \end{aligned}$$

Wherein Y_{sugar} is the average national sugar consumption per capita; *Coca Cola*, *Fanta Orange*, and *Sprite* denote the amount of sugar per 100ml; *GDP* is the gross domestic product per country; *KOFGI* is a globalization indicator; *Overweight* and *Obesity* denote the percentage of the population which is either overweight or obese; *Employment Service* shows the percentage of people employed in the service sector per country; *Median Age* is the median age per country; the *Sugar Tax Dummy* shows whether a sugar tax on sugar-sweetened beverages has been enacted per country; *Urban Pop* is the percentage of people living in cities per country; *Gender* is the WHO's Gender Inequality Index; *FDI* denotes the foreign direct investment into the food sector per country; *Price* expresses the average price of sugar-sweetened beverages per country; *Affordability* denotes the price of sugar-sweetened beverages relative to income; and ε is the error term.

6.b Variables

Five major variables, namely the sugar content per 100ml of Coca Cola, Sprite and Fanta Orange, the World Bank's country income group classification, as well as sugar consumption per capita per year, were already described above. For the remaining variables, the theoretical explanation of why they should be included, and the source of data will be described in more detail in this section. If possible, data for these variables stemming from 2022 have been utilized, as most of the utilized soft drink recipes stem from this time. If this is not possible, it is indicated in the following section.

Measurement of economic development

GDP per capita

The GDP per capita data is sourced by the World Bank. The World Bank calculates the GDP as the “sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products.” (World Bank, 2024b). In this calculation, the degradation and depletion of natural resources as well as the depreciation of fabricated assets, are not taken into account. Data from the year 2022 was taken into account to make it comparable to the Coca Cola, Fanta Orange and Sprite data (World Bank, 2024f). According to the theory underlying this thesis the relationship between sugar and GDP follows a sort of “Kutznetz curve”. This is to say that in poorer countries sugar consumption rises quickly and stagnates, or even falls in very rich countries. To emulate this in this model GDP is squared.

Measurement of globalization

KOF Globalization Index

Following the theory of the nutrition transition, globalization plays a central role in the average amount of sugar consumed. Thus, the KOF Globalization Index of the ETH University of Zurich is used to measure country-level globalization. This index takes economic, social and political dimensions of globalization into account and is comprised of 39 variables. These range from exports and imports of goods measured in percentage of GDP, to the number of embassies or the number of McDonald’s restaurants in relation to the population. The index is calculated each year by normalizing the collected panel data. It works on a scale from one to 100, in which 100 signifies the maximum value of a specific variable over all countries and the entire reporting period (since 1970). For this master thesis, the 2022 figures of this index were used (ETH Zürich, 2023).

Social System Changes

Overweight and Obesity

The average Body Mass Index (BMI) of a country and the BMI distribution within a country are good indicators for the nutrition transition (Finucane et al., 2011). Therefore, the prevalence of overweight and obesity are included in this model of the nutrition transition. To do so data from the WHO Global Health Observatory for the year 2022 is used. For the variable Overweight, this data denotes the percentage of adults aged older than 18 years with a Body Mass Index of 25kg per square meter or higher, and for obesity, the percentage of adults over 18 with a BMI of 30kg per square meter or higher. For both variables, the WHO uses an age-standardised rate to increase the comparability between countries (WHO, 2024).

Gender Inequality Index

As Baker (2020) discussed, one of the social system changes in the nutrition transition is caused by the changing position of women in society. Furthermore, globalization has often been connected to advancements in gender equality (Akhter & Ward, 2009). Therefore, the Gender Inequality Index, procured by the World Health Organization, is included in this analysis. The GII is a composite index, which reflects the inequality between women and men on a country level. It is measured in three dimensions: empowerment, reproductive health and the labour market. Health is measured through the adolescent fertility rate as well as the maternal mortality ratio. Empowerment is assessed through education attainment levels as well as the share of parliamentary seats held by women. In the labour market, female participation in the workforce is taken into account. The GII ranges between 0 (high equality between women and men) and 1 (high inequality between women and men). In the interpretation of this data, it is important to take the components of this index into account and keep in mind which aspects of equality between women and men the index does not measure. The utilized index indicators stem from the year 2022 (UNDP, 2024).

Median Age

The Median Age data is taken into account in this model, because, as described in the within country chapter, younger people tend to consume more sugar overall and sugar-sweetened beverages in particular (Bleich et al., 2018). Therefore, the median age might be an interesting variable when modelling the sugar nutrition transition. The data for the median age per country was sourced from the UN World Population Prospect (Population Division, UN, 2024). The utilized data is from the year 2022.

As is standard in developmental economics literature, the median, not the mean age, is taken into account, as this measure better expresses the midpoint of the population, thus giving a better image of the age distribution in a society looks and is more resistant to outliers (Ritchie & Roser, 2024)

Food System Changes

Urban population: Percentage of total population living in urban areas

As described in the theoretical section, countries' urbanization is a potent factor in their nutrition transition. Thus, the variable of urban population as a percentage of the total population is added to this model. Population is described as urban population if these areas are defined as urban areas by national statistical offices. Unfortunately, different classifications of urban or rural are used in different countries. The United Nations Population

Division aggregates this data annually. The sourced data stems from 2022 (World Bank, 2024g).

FDI in the food sector

The theoretical literature also clearly indicates that the presence of transnational food corporations and FDI in the food industry strongly influences a country's nutrition transition. To estimate this effect, the incoming FDI in the food sector is added as a variable. This data stems from the OECD database for FDI positions by economic activity. As the 2022 data for this variable was not available, the 2021 data was utilized (FAO, 2024a).

Employment in services as a percentage of total employment

As Popkin notes, one of the key factors of a change in Social Systems is a change in workplaces (2009); the importance of this factor is also confirmed by Ferretti and Mariani (2019). Therefore, this variable is chosen to represent the decrease of physically active work in the primary or secondary sector and the increase of employment in services along the nutrition transition. This data is aggregated by the ILO, which defines the service sector as consisting of “wholesale and retail trade and restaurants and hotels; transport, storage, and communications; financing, insurance, real estate, and business services; and community, social, and personal services, in accordance with divisions 6-9 (ISIC 2) or categories G-Q (ISIC 3) or categories G-U (ISIC 4)” (World Bank, 2024e).

Possible direct influences on sugar consumption

Sugar Tax Dummy

Another important variable, which might have an influence on the sugar content in beverages is sugar taxes. Starting in the 2010s, more and more countries have become aware of the grave negative side effects of sugar overconsumption and have thus enacted legislation taxing sugar in sugar-sweetened beverages. This of course has the potential to have a direct effect on the amount of sugar in sugar-sweetened beverages, which is why the effect will be explored separately for each variable. The data for sugar tax legislation stems from the World Bank Global Sugar-sweetened Beverage Tax Database. Data from 2022 was utilized and coded into a dummy variable (World Bank, 2024a). Only national sugar taxes were taken into account, as the sugar contents of the investigated beverages also only vary on a country level. There was no differentiation made between how the tax is enacted, calculated or how high the tax is, this of course leaves room for error. Due to the brevity of this research, unfortunately, this potential influence cannot be addressed in more detail.

Price and Affordability

The data for price and affordability of sugar-sweetened beverages are proxy variables for the price of sugar. The investigated relationship is, simply put, a demand function for sugar, which is why the price of sugar is one of the major factors theorized to impact demand. As, unfortunately, no data comparing the price of sugar per country could be found, this proxy is utilized. The data was generated by Ferretti and Mariani (2019) and stems from the year 2015. They generated the average market price of sugar-sweetened beverages, by dividing the total sales value per year and country through the total volume of sales. They further converted these prices to a common currency under purchasing power parity. The variable of affordability is a function of the price of sugar-sweetened beverages relative to the average income of this country, expressed in percent (Ferretti & Mariani, 2019).

6.c Results

The results of the regression can be found in the following Table 13.

Table 13

Nutrition Transition Regression Model 1 (40 included observations)

Variable	Coefficient	P-Value
Coca Cola	-3,094118	0,1653
Fanta Orange	1,324364	0,0839*
Sprite	0,178849	0,6384
GDP^2	-0.000000000196	0,7128
KOFGI	0,834789	0,0063***
Median Age	-1,033671	0,0091***
Overweight	-0,150253	0,7379
Obesity	0,179526	0,7719
Gender Inequality Index	-1,334168	0,9531
Employment Service	-0,376961	0,0455**
Urban Pop	0,219103	0,1132
Price	4,971951	0,0351**
Affordability	-1,858336	0,3287
Sugar Tax Dummy * Coca Cola	1,502105	0,0958*
Sugar Tax Dummy * Sprite	0,713728	0,3545
Sugar Tax Dummy * Fanta Orange	-2,486146	0,0214**

FDI	-0,020724	0,7857
Adjusted R-Squared		0,458048
Prob (F-Statistic)		0,009423***

Note. Data for this regression stems from the own research of the author (see annex), World Bank, 2024a; World Bank, 2024b; World Bank, 2024f; ETH Zürich, 2023; UNDP, 2024; Population Division, UN, 2024; World Bank, 2024a; World Bank, 2024g; FAO, 2024a; World Bank, 2024e; This regression was analysed using EViews as statistical software, and a $p < 0.1$ is statistically significant, a smaller p-value signifies a better performance. Asterisks represent the following: “*” $0.05 < p < 0.1$, “**” $0.01 < p < 0.05$, and “***” $p < 0.01$.

An especially pressing issue with this regression analysis is the low number of included observations. This is caused by the FDI variable, which only has 50 observations overall. After excluding this variable, the model for the next regression, Model 2, looks as follows:

$$\begin{aligned}
Y_{sugar} = & \alpha_0 + \alpha_1 Coca\ Cola + \alpha_2 Fanta\ Orange + \alpha_3 Sprite + \alpha_4 GDP^2 + \alpha_5 KOFGI \\
& + \alpha_6 Overweight + \alpha_7 Obesity + \alpha_8 Employment\ Service \\
& + \alpha_9 Median\ Age + \alpha_{10} Sugar\ Tax\ Dummy + \alpha_{11} Sugar\ Tax\ Dummy \\
& * Coca\ Cola + \alpha_{12} Sugar\ Tax\ Dummy * Fanta\ Orange \\
& + \alpha_{13} Sugar\ Tax\ Dummy * Sprite + \alpha_{14} Urban\ Pop + \alpha_{15} Gender \\
& + \alpha_{16} Price + \alpha_{17} Affordability + \varepsilon
\end{aligned}$$

Wherein Y_{sugar} is the average national sugar consumption per capita; *Coca Cola*, *Fanta Orange* and *Sprite* denote the amount of sugar per 100ml, *GDP* is the gross domestic product per country; *KOFGI* is a globalization indicator; *Overweight* and *Obesity* denote the percentage of the population which is either overweight or obese; *Employment Service* shows the percentage of people employed in the service sector per country; *Median Age* is the median age per country; the *Sugar Tax Dummy* shows whether a sugar tax on sugar-sweetened beverages has been enacted per country; *Urban Pop* is the percentage of people living in cities per country; *Gender* is the WHO's Gender Inequality Index; *Price* expresses the average price of sugar-sweetened beverages per country; *Affordability* denotes the price of sugar-sweetened beverages relative to income and ε is the error term.

Table 14*Nutrition Transition Regression Model 2 (83 included observations)*

Variable	Coefficient	P-Value
Coca Cola	-3,786025	0,0500*
Fanta Orange	0,143978	0,7992
Sprite	0,29218	0,7222
GDP^2	-0.00000000034	0,5605
KOFGI	0,374179	0,0701*
Median Age	-0,431666	0,0054***
Overweight	-0,183343	0,8254
Obesity	0,262969	0,5155
Gender Inequality Index	-7,838323	0,6490
Employment Service	0,030202	0,7813
Urban Pop	0,095492	0,2592
Price	-0,534470	0,6168
Affordability	-0,248806	0,3444
Sugar Tax Dummy * Coca Cola	0,256822	0,6663
Sugar Tax Dummy * Sprite	-0,058279	0,9317
Sugar Tax Dummy * Fanta Orange	-0,321948	0,6947
Adjusted R-Squared		0,380018

Note. Data for this regression stems from the own research of the author (see annex), World Bank, 2024a; World Bank, 2024b; World Bank, 2024f; ETH Zürich, 2023; UNDP, 2024; Population Division, UN, 2024; World Bank, 2024a; World Bank, 2024g; FAO, 2024a; World Bank, 2024e; This regression was analysed using EViews as statistical software, and a $p < 0.1$ is statistically significant, a smaller p-value signifies a better performance. Asterisks represent the following: “*” $0.05 < p < 0.1$, “**” $0.01 < p < 0.05$, and “***” $p < 0.01$.

As can be clearly seen in this analysis from the three main variables of interest, Coca Cola, Sprite and Fanta Orange, only Coca Cola shows any statistically significant effects.

Figure 12*Significant Johnson Neyman Plots of Coca Cola*

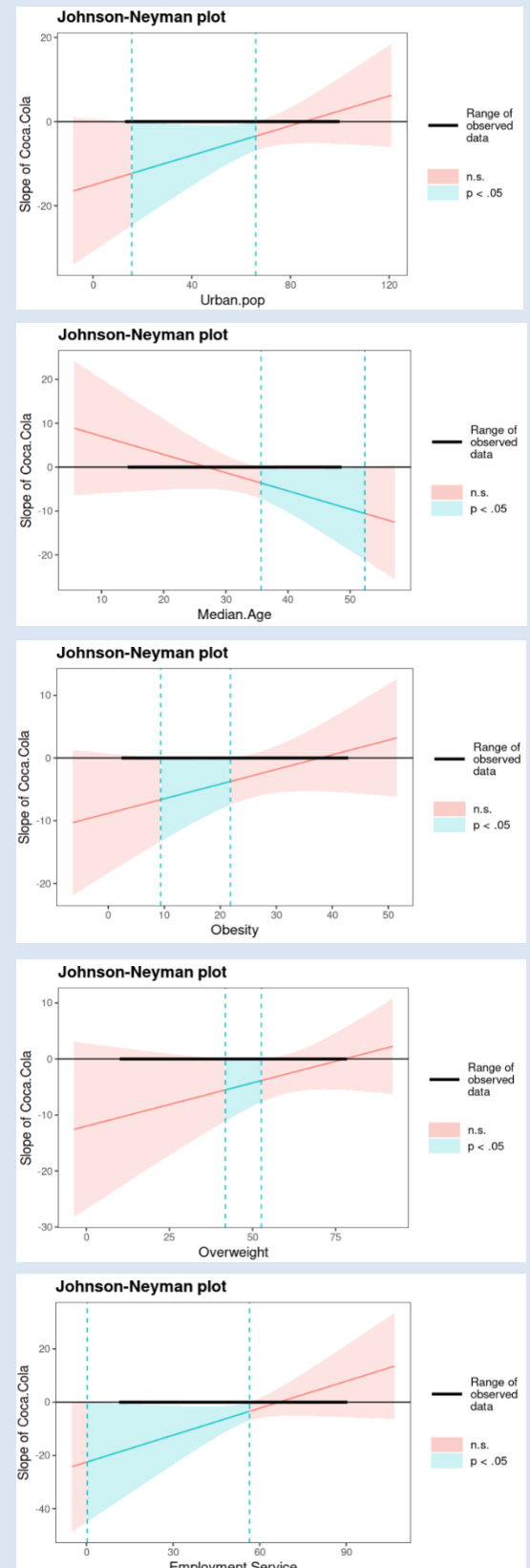
As Coca Cola is a significant variable, in a next step a series of Johnson Neyman Interval Analyses should determine under which conditions the moderation effect of this variable exists and which directions it has. These Johnson-Neyman intervals show that the relationship between the sugar content of Coca Cola and several other independent variables is significant within certain ranges.

There are no statistically significant effects between Fanta Orange and Sprite and any of the independent variables. Coca Cola shows statistically significant effects with urban population, median age, overweight, obesity and employment service.

According to the first Johnson-Neyman analysis the relation between the sugar content of Coca Cola and the median age of a country is significant between 35.66 and 52.36 years. In countries with a median age in this range the sugar content has a negative slope, which indicates that a higher median age is associated with a lower sugar content in Coca Cola.

There is a significant negative relationship between the percentage of overweight individuals in a country and the sugar content of Coca Cola in countries with between 41,83% and 52,65% of overweight population. A higher percentage of overweight individuals in a country can be associated with a lower sugar content of Coca Cola. The same effect can be found with obesity, here the range between 9,36% and 21,79% is statistically significant.

Finally, a significant negative relationship can be found between employment in the service sector and sugar content when the percentage of service employees in a country is between 0.26% and 56.47%. Higher



Note. The boxplots are based on sugar content measured in g per 100ml, the source of this data can be found in the annex. The Johnson-Neyman analyses plots indicate the size and significance of the slope of Coca Cola, Obesity, Overweight, Employment Services, Median Age and Urban Population throughout all observed levels of the variables. The coloured regions indicate 95% confidence intervals, significant effects are coloured blue.

employment in the service sector is associated with lower sugar content in Coca Cola.

After excluding all statistically insignificant variables the following regression model, Model 3, is posited:

$$Y_{sugar} = \alpha_0 + \alpha_1 Coca\ Cola + \alpha_2 GDP^2 + \alpha_3 KOFGI + \alpha_4 Employment\ Service + \alpha_5 Urban\ Pop + \varepsilon$$

Wherein Y_{sugar} is the average national sugar consumption per capita; *Coca Cola* denotes the amount of sugar per 100ml per country, *GDP* is the gross domestic product per country; *KOFGI* is a globalization indicator; *Employment Service* shows the percentage of people employed in the service sector per country; *Urban Pop* is the percentage of people living in cities per country and ε is the error term. The results of this regression analysis look like this:

Table 15

Nutrition Transition Regression Model 3 (104 included observations)

Variable	Coefficient	P-Value
Coca Cola	-3,493426	0,0265**
GDP^2	-0.000000000916	0,0103**
KOFGI	0,193708	0,0103**
Urban Population	0,149074	0,0121**
Employment Service	0,152869	0,0579*
Adjusted R-Squared		0,446813
Prob (F-Statistic)		0,000000***

Note. Data for this regression stems from the own research of the author (see annex), World Bank, 2024a; World Bank, 2024b; World Bank, 2024f; ETH Zürich, 2023; UNDP, 2024; Population Division, UN, 2024; World Bank, 2024a; World Bank, 2024g; FAO, 2024a; World Bank, 2024e; This regression was analysed using EViews as statistical software, and a $p < 0.1$ is statistically significant, a smaller p-value signifies a better performance. Asterisks represent the following: “*” $0.05 < p < 0.1$, “**” $0.01 < p < 0.05$, and “***” $p < 0.01$.

Finally, to test these results the model is checked for heteroscedasticity, which could invalidate the found results. The results of the employed Breusch - Pagan - Godfrey test show a clear probability of the F-statistic over a 5% confidence interval. Therefore, the null hypothesis, which is that no heteroskedasticity exists in the model, can be accepted.

The results of this regression indicate that there is an inverse relationship between Coca Cola and sugar consumption in a country. For every unit increase in Coca Cola, the average

consumed sugar decreases by 3.44kg, controlling for GDP, Globalization, Urbanization and the level of employment in the service industry. According to the adjusted R², this model explains 44,68% of the variation in sugar consumption.

6.d Preliminary Conclusion Research Question 2

As discussed before, only a few economic studies aim to model the nutrition transition of sugar consumption. Therefore, a wide array of indicators were chosen to represent this transition. The variables of overweight, obesity, median age per country and gender, which were all chosen to represent the social system changes, were not statistically significant. This is not entirely unexpected, as social system changes were the most difficult to research and find accurate indicators for. In contrast to food system change variables, which directly are affected by and effect the nutrition transition, these variables may influence general trends but are not directly linked to the nutrition transition. Although many of these variables are highly connected with globalization, the connection might be too indirect to cause statistical effects.

The food system change variable of FDI in the food sector was also not statistically significant. However, as discussed before, only 50 observations of this variable were available to the researcher at the time of writing this master thesis. Further, these countries were mostly high-income countries (29) and upper middle-income countries (14), centralized in Europe (30) (FAO, 2024a). Therefore, a more accurate global representation, might have an influence of the applicability of this variable in this model.

The sugar-sweetened beverage tax dummy also did not produce statistically significant effects, neither on its own nor in combination with the sugar content in each of the three beverages. As discussed before this dummy variable is a very fuzzy measurement, as it groups an incredibly wide array of different forms and extents of taxation together. Unfortunately, the scope of this thesis does not allow for a more precise measurement, as the global effects of the sugar tax on sugar-sweetened beverages are certainly a relevant aspect of this topic.

The variables of price and affordability of sugar sweetened beverages were also not statistically significant. As discussed before in this thesis these variables are used as proxy variables for the price of sugar per country. Ferretti and Mariani found that the price and the affordability of sugar sweetened beverages varied remarkably between countries of the same income group. This could potentially indicate that these variables were not suited to be a good proxy for sugar price (Ferretti & Mariani, 2019).

Factors which are the closest measurements of globalization, namely GDP, the KOF Globalization Index, Urbanization and Employment in Services, were highly relevant in this modelling. This is supported by the theoretical evidence of authors discussed in the theory section of the paper.

The most interesting discovery, however, is that whilst the average sugar content of Coca Cola was statistically significant, the average sugar content of Sprite and Fanta Orange was not. This reflects gravely on the first research question discussed in this paper.

The Sub-Research Question 2 asked in this part of the paper was “In how far are these variables statistically significant factors in the relationship between the average national sugar consumption and economic development?”.

It is now clear that Coca Cola has some statistical significance, which impacts the relationship of on the average national sugar consumption and economic development. Fanta Orange and Sprite do not have this effect.

7. Discussion and Conclusion

This master thesis set out to explore whether the sugar content of sugar-sweetened beverages in different countries could be utilised as an indicator of the preference for sugar in a product and thus as a variable, which can further help to explain the nutrition transition. Three globalized products were compared to various factors to answer the following research question:

“In how far is the demand for sugar content in a globally comparable product a significant factor in the relation between economic development and sugar consumption?”

To answer this question, two sub-questions were posed:

1. “In how far is the sugar content in Coca Cola, Sprite and Fanta Orange a good indicator for the national demand for sugar or sugar preference?”
2. “In how far are these variables statistically significant factors in the relationship between the average national sugar consumption and economic development?”

It was hypothesised that the sugar content of Coca Cola, Sprite, and Fanta Orange are good indicators for the local population’s preference for sugar content in products, as they are globally marketed products that have regionally adapted recipes. Further, it was hypothesized that there is a statistically significant relationship between a country’s average sugar consumption and economic development, in which the newly observed variable is a confounding variable.

It was explained at length and based on a substantial theoretical basis laid in a literature review why the author posits that Coca Cola, Fanta Orange and Sprite could be good indicators for a local sugar preference. However, the investigated data did not show any consistency between these three variables, or the variables and any other established trends related to sugar consumption, such as regional or economic patterns. Therefore, it was concluded that not all three variables can be a good predictor of regional demand for sugar at the same time.

After establishing a realistic economic model for the nutrition transition in Sub-Research Question 2 it was shown that only Coca Cola had a significant effect on sugar consumption. According to Model 2, the more sugar is consumed in a country, the less sugar is found in Coca Cola.

As Coca Cola is a significant variable, a series of Johnson Neyman Interval Analyses were employed to determine under which conditions the moderation effect exists and which directions it has. This moderation analysis showed that the variables of urban population, median age, overweight, obesity and employment service moderate the effect between sugar and Coca Cola sugar content significantly. The sugar content of Coca Cola and the median age of a country has a significant negative relation between 35.66 and 52.36 years. Between 41,83% and 52,65% of overweight individuals in a country there is a significant negative relation between overweight and the sugar content of Coca Cola. The same effect can be found with obesity, here the range between 9,36% and 21,79% is statistically significant. Finally, between 0.26% and 56.47% of employees in the service sector, a significant negative relationship can be found between employment service and the Coca Cola sugar content.

These statistical results indicate that the average sugar content in Coca Cola can be seen as a factor in determining a consistent indicator of preference for sugar in a single product in a population. It is unfortunately unlikely that this is the case, for two reasons.

First of all, the theoretical explanation of why Coca Cola, Sprite and Fanta Orange would make good indicators for local preference for sugar in a comparable product, which was given in the analysis of the Sub-Research Question 1, was laid out to explain the appropriateness of all three brands simultaneously. All three brands were hypothesised to be good indicators as they are highly glocalised, fitted to local market preferences and produced in similar ways. From a theoretical point of view, it is therefore not evident why only one of the three beverages, Coca Cola, would be a good indicator of sugar demand per product, while the other two brands would not.

Secondly, as became clear from the analysis of the sugar content in Coca Cola as part of Sub-Research Question 1, Coca Cola is a variable with very little variance. It is by far the most consistent of the three observed brands, with 68 out of 120 observations having the same

sugar content (10,6g), and a standard deviation of only 0,7g. In comparison to the standard deviations of Fanta Orange (2,99g) and Sprite (3,56g), this is remarkably low. Overall 57% of the observed Coca Cola beverages worldwide barely differ from each other with regard to their sugar content. Assuming the hypothesis of this thesis were correct, and Coca Cola would be a good predictor of demand for sugar in a comparable product, this would mean that in about two-thirds of the countries worldwide, the population's sugar preference is highly similar, if not the same. This stands in contrast to existing literature and general data on sugar consumption, which is why it is unlikely to be the case.

For these reasons, the research question “In how far is the demand for sugar content in a globally comparable product a significant factor in the relation between economic development and sugar consumption?”, will be answered as follows: There is no discernible effect of sugar content in a globally comparable product on the relation between economic development and sugar consumption.

7.a Theoretical Limitations

Naturally, this gives rise to an intriguing question. Considering the theoretical literature on the nutrition transition presented in this paper – why is there no clear curve-like relationship between sugar consumption and economic development, as discovered in Analytical Step 1? The answer to that might lie in the theory itself.

The theory of the nutrition transition also often called coca-colonisation, or McDonaldisation, posits a globally homogenous outcome of the effect of globalisation on diets. However, many studies have shown that global market integration does produce divergent and convergent dietary outcomes at the same time, depending on whether the country or individual level of diet measurement is utilized. Although more people consume processed foods, different types of people consume different types of processed foods stemming from different sources, influenced by different forms of marketing (Hawkes, 2006).

There is mounting evidence that, even though there is a global convergence of sugar consumption patterns, nationally, there is no single nutrition transition within the population. One of the main reasons globalization has such varying outcomes in the world is that the different circumstances and contexts in which the globalising processes occur. The same applies when it comes to the nutrition transition. Socioeconomic differences, cultural contexts, and bifurcations in the economy can explain the differing outcomes of similar processes (Baker et al., 2020). In high-income countries, poorer socioeconomic groups are particularly affected by worse dietary quality. This does not only lead to heightened obesity among these individuals but also exacerbates the number of chronic diseases and disabilities.

Studies have described a strong bifurcation of diets along socioeconomic lines, which also leads to the problem of double malnutrition (Batal et al., 2023).

This correlates with the convergence–divergence theory, which was discussed briefly in the theoretical section of this paper. Changes in diet do not occur evenly over in every country at the same time (Baker et al., 2020).

Even Popkin, the strongest proponent of the nutrition transition theory finds that the stages of “decreasing famine” “degenerative disease” and “behavioural change” he proposes do not follow a strict historical order. He claims that due to external factors, like stages of economic and demographic development, geography or socioeconomic class, a country might not necessarily undergo these stages in this exact order or might be in several of these stages at once (Popkin & Ng, 2022).

Furthermore, the stage of “degenerative disease” is not inevitable. In field experiments by Monteiro, it was shown that nutritional education counteracts growing numbers of obesity in low-income communities. By holding courses in Brazil about the importance of balanced nutrition, he was able to observe communities integrating the newly available processed foods better into their diets, and he could demonstrate a strong inverse relationship between education and obesity, in contrast to income (Garzillo et al., 2023).

The nexus between globalisation, the concentration of the food market and diet is a complex one. Although some experts perceive the food changes through globalisation as largely positive, for example through the avoidance of undernutrition and famines (Dollar, 2001; Feachem, 2001), others perceive globalization as having a predominantly negative effect on diets through the increasingly oligopolistic position of international food traders (Baum & Baum, 2016; Berlinguer, 1999, 1999). Of course, reality is not clear-cut, and the interactions between these factors are incredibly complex. Especially in different contexts, and these homogenous processes have highly heterogeneous effects. However, what has been observed clearly is that globalisation has had a stark impact on diets worldwide. Thus, it is important to understand these influences in order to address and capture the effects efficiently (Popkin, 2017).

In order to develop more accurate policy responses and fully understand the micro processes present in the nutrition transition, experts underline the importance of data on the actual consumption, which takes factors like socioeconomic class, occupation, sex, age or others into account. They further stress the importance of widespread research throughout different countries, especially in low and middle-income countries (Turner et al., 2013). The lack of data from these regions also proved to be a challenge in the data collection for this paper. There is a need for globally standardised dietary assessment instruments to accurately measure

changes and transition phases in nutrition, as current variables often do not measure ultra-processed foods adequately. Whilst sugar, sweeteners and sugar-sweetened beverages are already taken into account in the WHO's measurement tool for Infant and Young Child Minimum Dietary Diversity (IYCF-MDD) and the FAO's tool for Minimum Dietary Diversity for Women of Reproductive Age (MDD-W), this is not the standard in every dietary assessment instrument (Arora & UNICEF, 2021; FAO, 2024a). Furthermore, many existing surveys only take in-home food consumption into account. At the same time, however, out of home food consumption is gaining importance through the nutritional transition and underlying system changes and thus has to be adequately measured (Walls et al., 2018).

7.b Limitations of this Research

Of course, this research is also not without its limitations, which could be another reason for the inconclusive results of this study. As alluded to in the data section, this study only takes the sugar content in grams per 100ml of the sweetened beverages into account, as they are marked on the nutrition labelling of the product. This brings with it three distinct disadvantages.

First of all, as discussed at the beginning of this study, the sugar content of Coca Cola, Fanta Orange and Sprite is analysed without accounting for differences in taste, which might arise through the use of different ingredients as sweeteners. Coca Cola, for example, is sweetened in different countries by molasses, high-fructose corn syrup, syrups, caramels and other types of sugar confectionery, in addition to regular sugar (Coca Cola, 2024). However, different types of calory adding sweeteners can taste sweeter or less sweet. For example, in recent years there has been a trend in the USA, through which Mexican Coca Cola became a popular import product, because it was claimed that Coca Cola from Mexico tasted sweeter or better than products from the same brand bottled in the US, even though the sugar content of both products is similar according to the official nutrition information provided by Coca Cola. This could, according to commentators, be traced back to the difference in sweetener used in the two products. Whilst Coca Cola in the USA is sweetened with high fructose corn syrup, Mexican Coca Cola is produced using cane sugar, which has a higher percentage of fructose than corn syrup (Nannestad, 2022). These differences in taste cannot be accounted for in the current study but could have an influence on the actual level of sweetness in products made by the Coca Cola Company.

Secondly, several studies have found that the total sugar content of sugar-sweetened beverages often varies drastically from the given nutritional information by the producers. Soft drinks often have more or less sugar than the nutrition label would indicate. Furthermore,

although only some labels explicitly mention the type of sugar utilized in the beverage, this information is not always correct. Additionally, fructose is often not accounted for in the total sum of sugar in the nutritional information, although it is as much of a sugar as other caloric sweeteners. Although there are national guidelines on the use of sugar labelling, this is not the case in every country of the world (Ventura et al., 2011). This is to say that, as the author does not have the resources to chemically verify the information of the nutritional labels of Coca Cola, a certain margin of error should be kept in mind.

Thirdly, an important factor this study could not take into account is the market positioning of Coca Cola, Fanta Orange and Sprite per country. As sales numbers are not publicly available, and research into the exact standing of a product in every national context would have been too extensive, this factor was not discussed in detail. However, this might be a good indicator of how representative the sugar content in Coca Cola is for the total population of a country. For example, in Austria, Coca Cola is a mid-level product, with both higher-end Cola beverages (for example Fritz Cola, Red Bull Cola or Fentimans Cola) and cheaper versions of Coca Cola (for example, Freeway Cola or River Cola) available freely and widely. Quite a different picture could be painted in Cote d'Ivoire, where Coca Cola was for 25 years the sole Cola beverage, until the bottling company of Coca Cola Solibra decided to offer a cheaper alternative to the Coca Cola brand called "Worldcola". This decision was made because Coca Cola is mainly regarded as a luxury brand in Cote d'Ivoire (Africa Intelligence, 2022).

7.c Conclusion

In conclusion, this thesis has aimed to illuminate the complexities inherent in the nutrition transition. A statistical model was built using extensive data gathered from over 120 countries. By performing a series of analyses, it was concluded that it could not be proved convincingly that the factor of regional demand for the amount of sugar in a product can be measured through Coca Cola, Sprite and Fanta Orange. However, this raises interesting complexities, especially pertaining to limitations like within-country differences, that are a relevant contribution to the current literature on the nutrition transition. Despite an innovative approach to the topic, the inherent limitations stemming from the scope of this research, as well as the unavailability of sufficiently concrete data, have impeded this research.

The complexity of nutrition transitions and their apparent lack of cohesion in international comparisons make them more difficult to research on a global level. Given the relevance of this topic, it is imperative to continue using economic and political research methods to facilitate more robust analyses of nutrition transitions and their effects.

This thesis demonstrates the importance that should be given to the overconsumption of sugar and the role of sugar-sweetened beverages. While the specific variables which were hypothesised to be relevant predictors did turn out not to be reliable indicators, this research can guide future efforts to better model shifts in sugar consumption patterns. It is hoped that this can aid in understanding the nutrition transition and in designing effective policy confronting the challenges posed by overconsumption of highly processed and sugar-rich food.

8. Bibliography

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9. Annex

This table indicates the source for the data utilized in the regression analyses.

Name	Source	Year	Link
GDP per Capita	World Bank	2022	https://data.worldbank.org/indicator/NY.GNP.PCAP.CD
Country Income classification World Bank	World Bank	2023	https://data.worldbank.org/indicator
Sugar contents per Sugar-sweetened Beverage (Coca Cola, Fanta Orange, Sprite)	Various	Various	Various - see column "Source" and "Notes" in Tab "Original"
Sugar Food supply quantity (kg/capita/yr)	FAO	2021	https://www.fao.org/faostat/en/#data/FBS
% of Population living in Urban area	Data from database: World Development Indicators	2022	https://databank.worldbank.org/reports.aspx?source=world-development-indicators#
Sugar Tax Dummy - national tax on SSB	World Bank	2023	https://datacatalog.worldbank.org/search/dataset/0063310
Median Age	UN Population Data	2021	https://population.un.org/wpp/Download/Standard/MostUsed/
FDI inflows to Food, Beverages and Tobacco	FAO	2021	https://www.fao.org/faostat/en/#data/FDI
Prevalence of underweight among adults, BMI < 18 (age-standardized estimate) (%)	WHO	2021	https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/body-mass-index
Prevalence of overweight among adults, BMI >= 25 (age-standardized estimate) (%)	WHO	2021	https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/body-mass-index
Prevalence of obesity among adults, BMI >= 30 (age-standardized estimate) (%)	WHO	2021	https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/body-mass-index
KOFGI	ETH Zürich	2021	https://kof.ethz.ch/prognosen-indikatoren/indikatoren/kof-globalisierungsindex.html
GNI per capita, Atlas method (current US\$)	World Bank	2022	https://data.worldbank.org/indicator/NY.GNP.PCAP.CD
Employment in services (% of total employment) (modeled ILO estimate)	World Bank	2022	https://data.worldbank.org/indicator/SL.SRV.EMPL.ZS
Gender Inequality Index	UN HDR	2022	https://hdr.undp.org/data-center/thematic-composite-indices/gender-inequality-index#/indicies/GII
Sugar-sweetened beverage prices (PPP \$ per litre)	Fabrizio Ferretti, Michele Mariani	2015	https://globalizationandhealth.biomedcentral.com/articles/10.1186/s12992-019-0474-x#Sec7
Sugar-sweetened beverage affordability (Soft drink relative income price, %)	Fabrizio Ferretti, Michele Mariani	2015	https://globalizationandhealth.biomedcentral.com/articles/10.1186/s12992-019-0474-x#Sec7

