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Identifying the effect of macroeconomic factors in cardiovascular diseases and diabetes.

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ABSTRACT (SUMMARY)

Purpose and objectives: The main objective of this work is to identify the effect of the macroeconomic determinants of obesity in the comorbidities of obesity. The present research has the intention to provide more evidence on the topic and inspire nontraditional approaches for the study of the comorbidities of obesity.

Methodological framework: The modernization theory and the world systems theory are used as a framework to relate different macroeconomic determinants of obesity with their impact in the total number of deaths attributed to cardiovascular diseases and diabetes type 2.

Results: Using an error correction model with a panel dataset of six countries over a period of 25 years (1995-2019) it is found that food exports and foreign direct investment in the food sector from the United States to the countries in the dataset are not related to the deaths attributed to cardiovascular diseases and diabetes type 2 in the short run, however the analysis demonstrates a negative relation between cardiovascular diseases and income inequality.

Discussion: Given that the findings of this work are based on the analysis of broadly defined macroeconomic measures, more in depth research on the long and short run consequences of growth, and distribution of income on obesity and its related effects, such as the total number of deaths attributed to cardiovascular diseases and diabetes type 2 is needed.

1 Introduction.

The main objective of this work is to identify the effect of the macroeconomic determinants of obesity in the comorbidities of obesity. The specific objective consists in the construction of a model based on the modernization and world systems theories to explore the relation of the macroeconomic determinants of obesity and the deaths attributed by cardiovascular diseases (CVDs) and type 2 diabetes, to achieve this a non-stationary panel data model is computed using data from Canada, Mexico, Colombia, Brazil, Peru, and Turkey using Stata 16 for a time period of 25 years. The present research has the intention to provide more evidence on the topic and inspire nontraditional approaches for the study of the comorbidities of obesity.

Obesity is defined by the World Health Organization (WHO) as the abnormal or excessive accumulation of fat in the body that may impair health (1998), it is also a risk factor associated with noncommunicable diseases such as CVDs and type 2 diabetes (WHO, 2021a) it is also a condition with multiple dimensions that produces not only health related consequences on individuals but demographic and socioeconomic repercussions on low, middle and high income countries (WHO, 2021b). The causes of obesity can be environmental, socioeconomical or individual (Bleich et al., 2008; Danson & Mccarthy, 2019; WHO, 2021b; Yazdi et al., 2015). However, while obesity is commonly seen as the outcome of either genetics or the decisions of an individual, the increase of obesity rates in specific regions of the world (Yach et al., 2006) shows that the role of environmental and socioeconomical factors should not be overlooked. In this work two theories that explain these macroeconomic determinants will be reviewed, these theories receive the name of the modernization theory and the world systems theory.

These two theories are condensed into an error correction model (ECM), which is used for data with a common stochastic trend (cointegrated and non-stationary variables) in order to estimate both the long-term and short-term effects of a time series over other time series. The ECM technique is used because the database created for this work uses a time dimension of 25 years in which non-stationarity is expected. ECMs are named this way to point out that the error (the last period deviation from a long-run equilibrium) influences the short run. Therefore, ECMs estimate the speed in which the explained variable returns to equilibrium after changes in the regressors.

The selection of the countries of Mexico, Canada, Colombia, Brazil, Turkey, and Peru is motivated by their similarities to Mexico in one way or another (Escobar et al., 2006; Ford & Mokdad, 2008). Five of this countries are upper middle-income economies, four of which are in Latin-America and have gone through similar economic and social changes during the last decades. Mexico is selected due to the vast amount of literature about the "exporting" of obesity from the United States to Mexico after the sign of the North American Free Trade Agreement (NAFTA) (Baggio & Chong, 2020; Clark et al., 2012; Giuntella et al., 2020; Otero et al., 2018; Popkin & Reardon, 2018). In the case of Canada, it is chosen for belonging to the same trade agreement while being a developed country with its own health and population dynamics. Turkey is selected for its similarity to the Latin-American countries that are pick for this document, being an upper middle-income country that has close political and geographic ties to a high world influence region, being the United States for Latin America and the European Union in the case of Turkey.

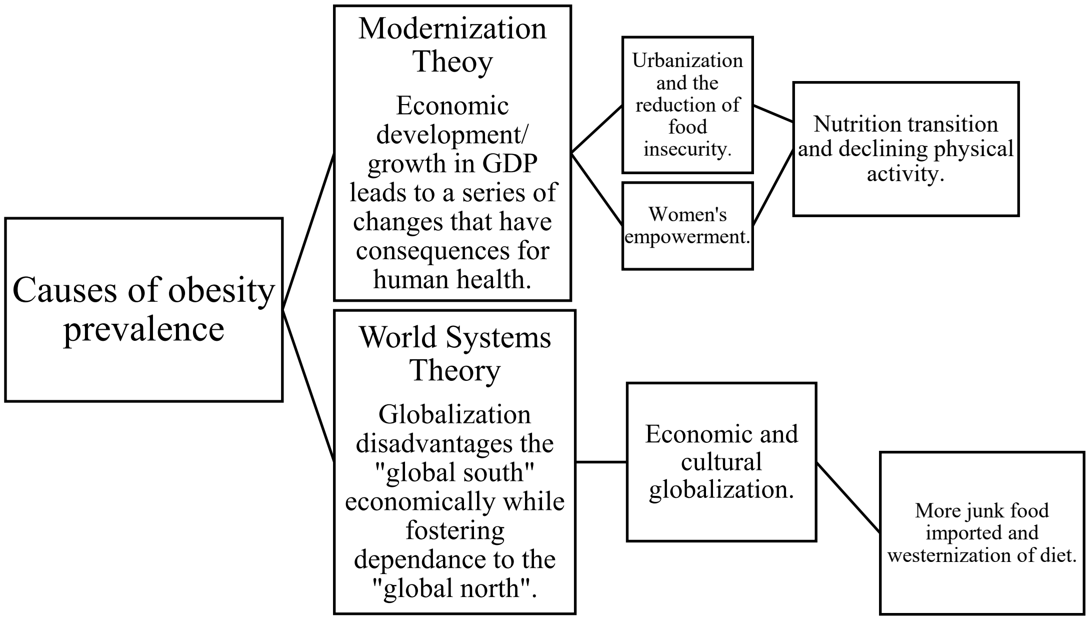
This document is organized as follows: chapter 2 offers some background about the main two theories discussed in this document, in chapter 3 the main mechanisms behind the macroeconomic determinants of obesity are discussed, chapter 4 is a brief characterization of the determinants mentioned in chapter 3, presented with an emphasis on Mexico, chapter 5 introduces a model in line with the objective of this work, and finally chapter 6 extends a discussion over the results obtained and their limitations.

2 Background.

The idea that the increase of unhealthy food consumption is motivated by the increase of food availability, food variability and income growth is what constitutes the backbone of the modernization theory (Fox et al., 2019). This theory backs up the notion that economic development and economic growth lead to a series of changes that have consequences in living standards, democratization, social mobility, and overall wellbeing. This perspective remit us to the concept of "nutrition transition" proposed by Popkin (1993) and followed by other authors (Caldwell, 1993; Frey & Field, 2000). For Popkin (1993) nutrition transitions are changes in diet motivated by increased income that leads to weight gain and chronic illness. Additional important factors that are often mentioned in the literature and are linked to the rise of obesity according to the modernization theory are the increase of women's empowerment, the escalation of urbanization rates and the westernization of the diets of populations in low and middle income countries through marketing and expansion strategies of food companies (Pingali, 2004; Watson & Caldwell, 2004; Ram, 2004).

In contrast, the world systems theory considers that food choices are constraint by the economic system. It regards that choices are inserted in a food system where firms take oligopolistic behaviors backed by governments of global north countries that set policies that directly influence the behavior consumers from global south countries (Otero et al., 2018). Particular attention is placed in the structural economic conditions of developed and developing economies where the former obliges the latter to behave in a particular way, to follow an economic a role(Harvey, 1995; Kiely, 2017; Herath, 2008), according to this theory, these structural conditions lead to a limitation in food choices which manifests in every component of the food system: farms, processing stages, logistics, retail and food services such as restaurants, fast food and even mobile-app delivery services (Bleich et al., 2008; Friel et al., 2013; Vogli et al., 2014). Figure 2.1 shows the causes of obesity prevalence according to both theories.

Figure 2.1- Theories on obesity prevalence.



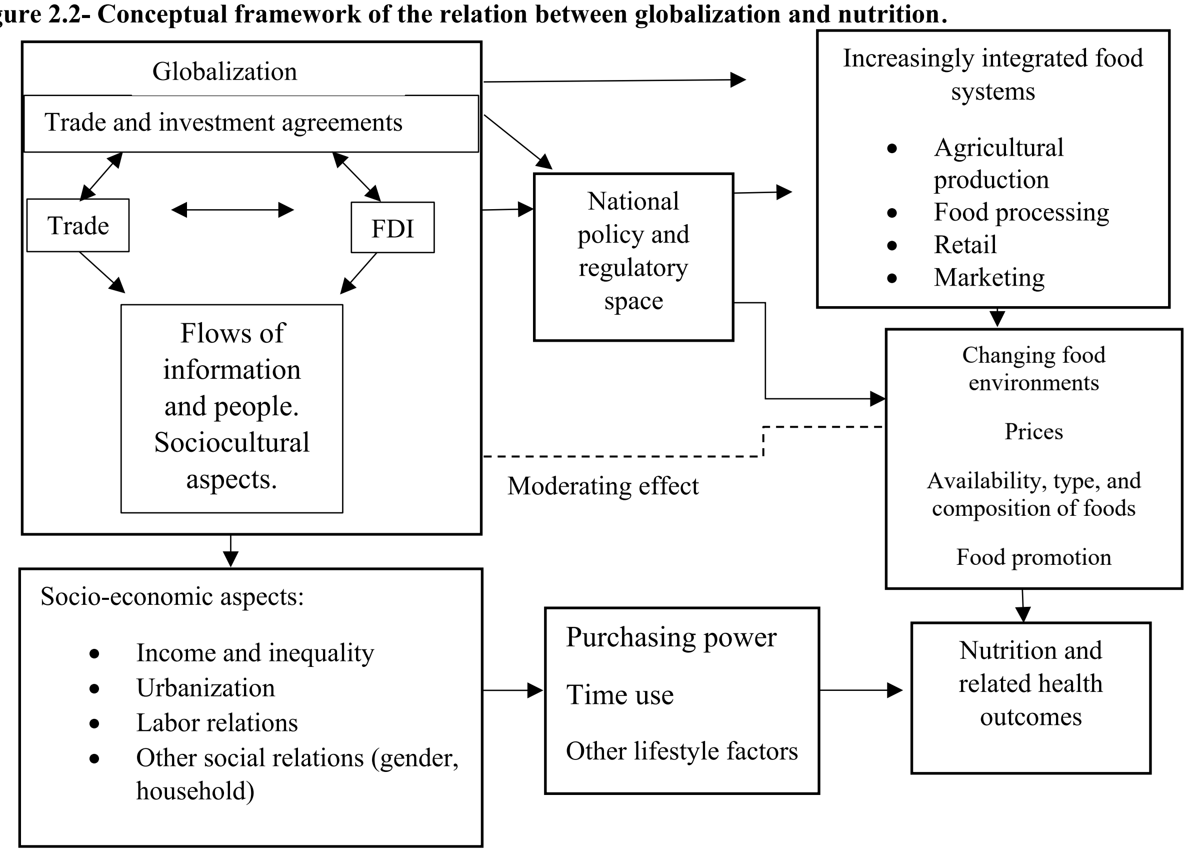
Source: Adapted from Fox et al., 2019.

The idea of an alliance between the two literatures has been explored by Popkin & Reardon (2018), the researchers consider that diet changes generally occur in a two-way causality, sometimes happening in parallel to other economic or social changes but always taking place as complex relations. As shifts in the food system (supply) induce changes in the demand of food products and vice versa, changes in the economic sphere have interactions with changes in the social sphere constantly revolutionizing the ways of eating and its cultural meanings. Popkin & Reardon (2018) recognize some positive effects on the food system that were motivated by these interactions in the last decades of globalization such as the reduction of the cost of food, the de-seasonalization of certain foods, the reduction of preparation time for home meals and the increasing availability of food options around the globe although these benefits are not accessible to every single human being. In a similar position to that of Popkin & Reardon, Fox et al. (2019) notes that not one single theory explains the whole reality which is much more complex and variant.

More complex approaches that take into consideration the perspective of the globalization process exists. Cuevas Garciá-Dorado et al. (2019) offers a systematic review of the quantitative literature behind trade liberalization and nutrition, not only covering obesity but also malnutrition in all its forms (undernourishment, micronutrient deficiencies, overweight) while also providing a new conceptual framework based on Labonte & Shrecker (2007), McCorriston et al. (2013) and, Friel et al. (2013). The main contribution of this conceptual framework is its ability to condense complex relations between concepts to paint a clearer picture about the drivers of obesity and other nutrition related health outcomes. However, the determinants that are showcased are the same that were previously identified in both the world systems theory and the modernization theory without giving a specific weight to each of them (Figure 2.2).

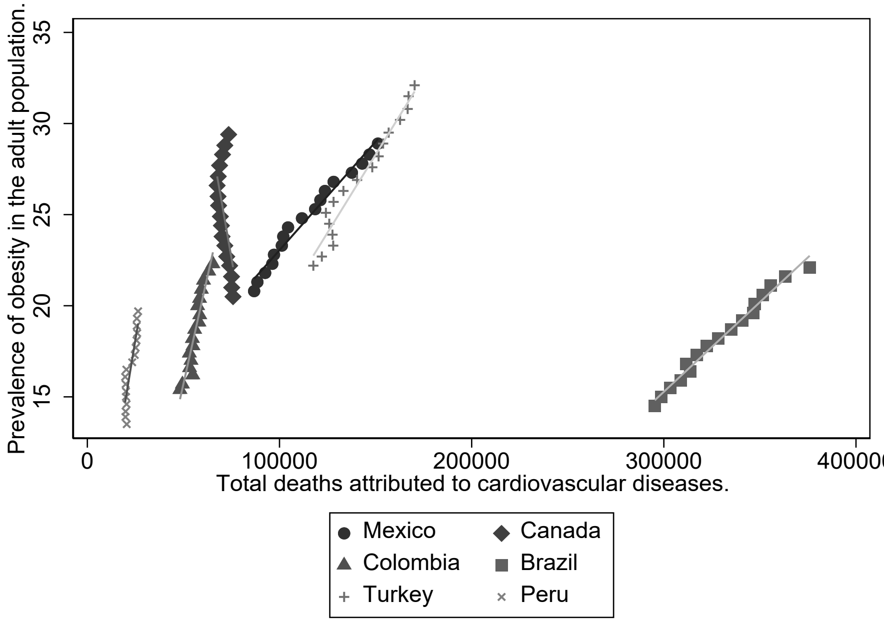
While studies showing the relation of the macroeconomic determinants to obesity at country level do exist (An et al., 2020; Cuevas Garciá-Dorado et al., 2019), they often have to extrapolate a significant amount of observations in both the dependent (percentage of population with obesity and body mass index [BMI]) and independent (determinants of obesity) variables in models to counter measure the sparsity of measurement of the variables at country level while only being able to access to relatively small periods of time, a problem that the use of the total deaths caused by the comorbidities of obesity does not suffer from. In fact, the link between obesity and CVDs and type 2 diabetes has been well established by the medical and nutritional sciences (Pi-Sunyer. & Xavier, 1999).

Figure 2.2- Conceptual framework of the relation between globalization and nutrition.



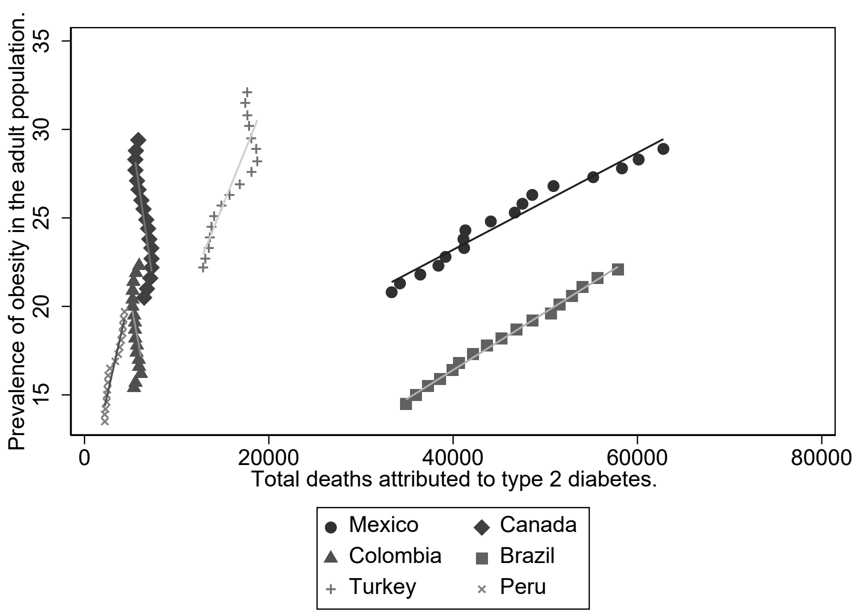
Source: Adapted from Cuevas Garciá-Dorado et al., 2019.

Figure 2.3- Prevalence of obesity in the adult population against total deaths attributed to cardiovascular diseases from 2000 to 2016.



Source: Own elaboration with data from IHME and FAOSTAT using STATA 16.

Figure 2.4- Prevalence of obesity in the adult population against total deaths attributed to type 2 diabetes from 2000 to 2016.



Source: Own elaboration with data from IHME and FAOSTAT using STATA 16.

The correlation between the deaths attributed to CVDs and type 2 diabetes and obesity can be appreciated through a correlation analysis performed for the selected countries in Figure 2.3 and Figure 2.4. Data on total deaths is sourced from the Global Burden of Disease Collaborative Network based out of the Institute for Health Metrics and Evaluation (2020) while data on the prevalence of obesity in the adult population (18 years and older) was obtained from the FAOSTAT Suite of Food Security Indicators (2021).

3 The macroeconomic determinants behind the obesity epidemic.

This section reviews the macroeconomic determinants of overweight and obesity along with type 2 diabetes and CVDs according to both the modernization theory and the world systems theory, the factors identified in the former are a combination of micro and macroeconomic, food availability, income growth, decrease of time at home, the effects of media and marketing on food consumption, women's growing empowerment in developing countries and urbanization, while in the latter the factors recognized are export flows and Foreign Direct Investment (FDI) flows from global north countries to global south countries. First the world systems theory is analyzed.

3.1 Foreign Direct Investment

During a systematic review of the literature that associated Foreign Direct Investment with obesity, Cuevas Garciá-Dorado et al. (2019) found that, overall: "FDI might be associated with an increased consumption of sugary and highly processed foods and increases of overweight and obesity in low- and middle- income countries in particular", interestingly, other authors such as Miljkovic et al. (2015) have found that FDI only show little correlation with global obesity on low- and middle- income countries while no link was found on high income countries. When FDI enters the food sector, which started to become increasingly common after the mid-1980s (Hawkes, 2005), the production, distribution and consumption patterns change and normally a demand shift into the more capital intensive highly processed foods is observed, which shows that FDI is a technology transfer (Borensztein et al., 1998) that is managed and controlled internationally (Siegel, 2016).

Some authors such as Otero et al. (2018) assert that there is evidence that supports the idea of the creation of "policy links" when trade liberalization policies that allow FDI flows take place in global south countries. These links chains condition the demand of food in global south countries to the agricultural policies of global north countries effectively making global north policies transcend their center of action to other markets and producing a "neoliberal diet" that is highly caloric with low nutritional value for the economically disadvantaged population while varied and nutritious for the rich population. These links can also be technological, as productivity increases attributed to technological change in global north countries can be crucial in the diet shifts of peripheric countries, even more if these advancements are not homogeneous across the food system as productivity spikes in a subsector may lead to diet distortions in other countries depending on trade relations and household income just in Canada and the United States from the 1980s to 2008 the price of vegetables and fruit increased disproportionately relatively to sweets and fats (Darmon & Drewnowski, 2008), situation that can be particularly damaging to lower income households that suffer from other negative environmental factors such as low education levels and work in some occupations that might make them more vulnerable to negative health outcomes caused by diet changes brought about by price changes introduced by increases in relative productivity across food industries (Beaulac et al., 2009).

Other examples of how FDI can introduce changes into food systems are related to the processes of globalization and urbanization as well, classic examples being McDonald's and Walmart. But these are not the only examples of how urbanized areas are related with poor health outcomes and general unhealthy lifestyles, Popkin (1993) argues that a nutritional transition takes place when economic growth leads to lower rates of physical activity and a higher consumption of fats and sugars due to a higher income, during the last two decades of the XX century this process has been speeded up in urban areas where diets are distinctly different as those from rural areas (Mazengo et al., 1997; Popkin, 1998; Pretorius & Sliwa, 2011), as Popkin (1999) notes, urban diets are correlated with higher levels of obesity and chronic disease due to an increased reliance on cheap, highly processed food commodities that are consumed by the urban poor, more so in low-income countries where higher shares of urban poor exist relative to urban poor populations in middle-income and high-income countries (Schram et al., 2013) and where higher barriers to access healthy food exists, barriers such as the lack of personal transportation to access wholesale and discount supermarkets that can provide more options like fresh meat and fresh produce at affordable prices or barriers like the lack of infrastructure for cold chains and storage capacity in some low-income countries, in the case of having these cold chains then the potential for increasing variety and availability at lower prices would exist (Kennedy, 2011).

3.2 Urbanization

Barriers to food accessibility are not the only contributor to higher obesity rates in urban areas, for example, in middle- and high-income countries higher levels of supply of low-quality food products can be found in urban areas as food firms can benefit from better infrastructure and larger markets that rural areas lack (Schram et al., 2013). In other places with different economic conditions such as Kenya, slum-dwellers in urban areas consume more street food than those in low-middle income neighborhoods in response of the low prices, situation that does not occur in rural areas (Van 'T Riet et al., 2001). Schram et al. (2013) claim that these dynamics are especially worrying in countries with high urbanization rates that are in the process of creating their own food industries, often owned by transnational food corporations that have the power to change local diets due to lower prices and higher food availability (Bourne et al., 2002; Pretorius & Sliwa, 2011).

Other changes that escalating urbanization rates may produce and can be mentioned are shifts in lifestyles. In urban areas these changes can consist in an impediment for the preparation of home cooked meals because of the decreased time at home. Stress is another factor of interest that could contribute to higher rates of obesity, as Huneault et al. (2011) suggests, stress related to the pressures of living in an urban environment compared to living in a rural one may generate a lifestyle that leads to hyperphagia (an abnormal increased appetite for food) and an overall lower decrease of energy expenditure.

3.3 Women's empowerment

Additional contributors to higher obesity rates are identified by other authors (Anderson et al., 2003; Brown et al., 2010; Cawley & Liu, 2012; De Soysa & Lewin, 2019; Fox et al., 2019; Gwozdz et al., 2013) in the empowerment of women and in the growing number of laboring women depending on the society.

At an individual level Anderson et al. (2003) establish that a child is more likely to be obese or overweight if his or her mother works more hours per week, Anderson et al. also indicate that a mother's socioeconomic status is directly correlated with the impact of every worked hour on the children's overweight level, while Brown et al. (2010) show that the impact of a mother's working time on her children's overweight status differs in relation to the children's age, children aged 4-5 years old are the most affected, Cawley & Liu (2012) also found plausible indirect mechanisms that associate maternal employment and childhood obesity, these mechanisms being the amount of time the mother supervises children, cares for children, goes grocery shopping and cooks. Gwozdz et al. (2013) also investigated the effects of maternal employment on obesity and little evidence was found between any association of maternal employment and childhood obesity, diet, or physical activity, nonetheless a relation between household poverty and children's obesity was found. It is important to mention that all these studies were performed for high-income countries.

At the macro level, De Soysa & Lewin (2019) found no relation between the population share that is overweight and the level of female empowerment that is measured by the United Nation's Gender Inequality Index, the absolute level of empowerment as measured by the VDEM data or the World Bank's Gender Parity Index, however they did realize that increasing female empowerment reduces the share of obese women. Nevertheless Fox et al. (2019) performed a study using a longitudinal dataset that covers 190 countries from 1980 to 2008 and found that women's empowerment was one of the most consistent and strongest predictors of mean BMI in countries over time, it was also found on their study that other variables for women's empowerment are positively and significantly related to mean BMI, variables such as women's labor force participation, women's social rights and women's education.

3.4 Others

The paper of information flows and media (television and social media) on the demand of food products as a potential mechanism to increase the probability of an individual to be overweight or obese should not be overlooked. Oberlander et al. (2017) found that available animal protein, sugar and mean BMI are significantly affected in a positive way by the availability of television and internet in a region, likewise Robinson et al. (2015) observe that the availability of television and internet does not only positively impact mean BMI on a region but specially impacts children, which are more prone to develop CVDs at an older age as a consequence of obesity similarly Coates et al. (2019) report that children that watch Instagram and YouTube content from food influencers are prone to consume larger amounts of unhealthy snacks in comparison to those children that watch nonfood influences or do not watch influencers at all.

All these past examples are forms in which the nutritional transition (Popkin, 1993) expresses itself. It is relevant to indicate that even if just higher income is mentioned in the original concept of nutritional transition the main concept behind it is in reality economic development (Nandi et al., 2014) as obesity is not a condition that is obtained in the short term but builds over time and normally needs to be constantly sustained, therefore it is critical to comprehend the effects of poverty and economic inequality on obesity rates. Janković et al. (2015) identifies that socioeconomic differences in cardiovascular health can be mostly explained by educational level and employment status. However, some studies show that the association between inequality within countries and obesity is only significant between high income countries and that more evidence is needed to obtain better comprehension about the relation between inequality and obesity in low and middle income countries (de Mestral & Stringhini, 2017; Vogli et al., 2014).

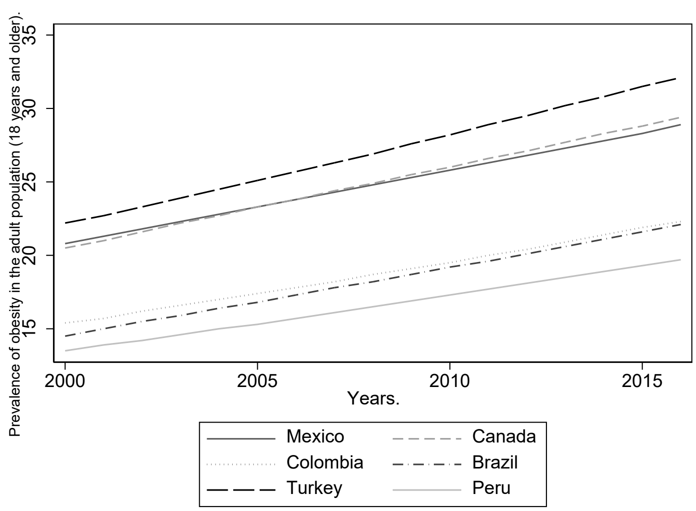
The nutritional transition seen in the last few decades in developing countries of Asia, Africa and Latin America has been fueled not only by higher income levels but also by higher food availability and food accessibility due to FDI, trade, urbanization, economic development, and other characteristics of globalization such as women´s empowerment and omnipresent marketing campaigns all over the media. All these determinants have led individuals to consume a greater variety of foods with a higher energy take that lack the necessary micronutrients for a healthy lifestyle which ultimately leads to obesity (Kennedy, 2011) and comorbidities. Nonetheless it is important to comment that the relation between every of these variables and obesity depends in individual and cultural contexts (Fox et al., 2019) but the macro impacts of the variables recognized by both the world systems theory and the modernization theory on obesity have been well documented (An et al., 2020; Cuevas Garciá-Dorado et al., 2019).

4 The nutrition transition in Mexico.

In this chapter a brief descriptive analysis of the different determinants mentioned in chapter 2 is offered for all the countries sampled in this study with an emphasis on Mexico's own nutrition transition after the sign of the NAFTA. A full description of the variables used in this chapter is offered in chapter 5.1. The integration of the Mexican economy into the global sphere due to the sign of the General Agreement on Tariffs and Trade (GATT) and the NAFTA brough important changes into the Mexican food system, these structural changes were in turn motivated by the Mexican debt crisis of 1982 which led Mexico towards attempting to apply the Washington Consensus in 1989 (Fluharty, 2006) which ultimately resulted in an increase in the availability of imported foods and beverages at lower prices per calorie (FAO, 2006). The new configuration of the Mexican food market changed the consumption patterns of the Mexican population and generated a rapid growth of obesity, before these changes, in 1993 women from 20 to 69 years old that were obese composed 25% of the population of women of their cohort, by 2018 the women that were 20 years old or older and that were obese represented 40.2% of the total population of women over 20 years old (INEGI, 2018; Villa et al., 2004).

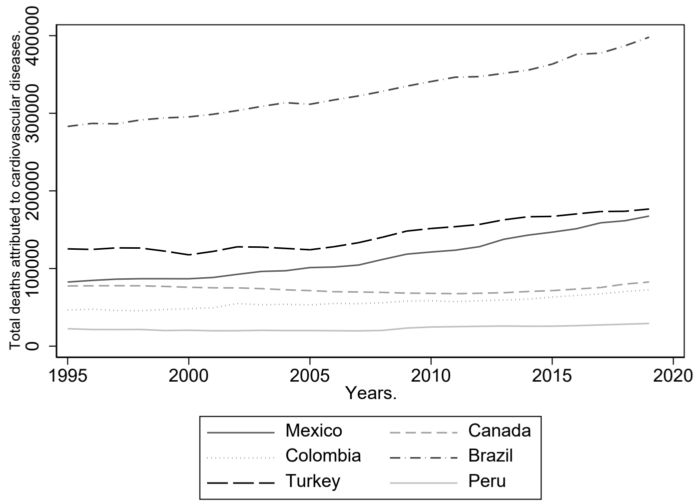
Studies that try to analyze the evolution of a country's mean BMI or a country's change in the obesity rates of its population and its determinants (An et al., 2020; Cuevas Garciá-Dorado et al., 2019) come with the handicap of not being able to perform a year by year analysis of a country, as official surveys often change population segments or may lack the same periodicity, just in the case of Mexico four different surveys were realized from 1995 to 2019, ENN-II in 1999 and ENSANUT in 2006, 2012 and 2018 changing the definition of population segment in 1999 from "women between 12 to 49 years old" to 2006 "women between 20 to 69 years old" to 2018 "women from 20 years old onward". For this reason, FAOSTAT offers an estimation of the evolution of obesity in the adult population for different countries, however this estimation is available only for the period of 2000 to 2016. Figures 4.1, 4.2 and 4.3 show for the countries sampled in this study, the evolution of obesity from 2000 to 2016 according to the FAO and the evolution of the deaths attributed to diabetes type 2 and cardiovascular diseases in the same group of countries from 1995 to 2019 accordingly. Information before 1995 is not available

Figure 4.1- Evolution of obesity in the adult population in selected countries from 2000 to 2016.



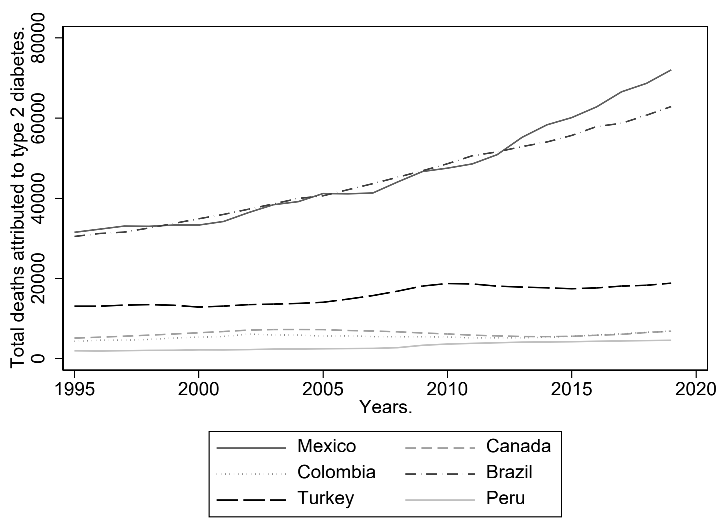
Source: Own elaboration with data from FAOSTAT using STATA 16.

Figure 4.2- Evolution of total deaths attributed to cardiovascular diseases in selected countries from 1995 to 2019.



Source: Own elaboration with data from IHME using STATA 16.

Figure 4.3- Evolution of the deaths attributed to diabetes type 2 in selected countries from 1995 to 2019.



Source: Own elaboration with data from IHME using STATA 16.

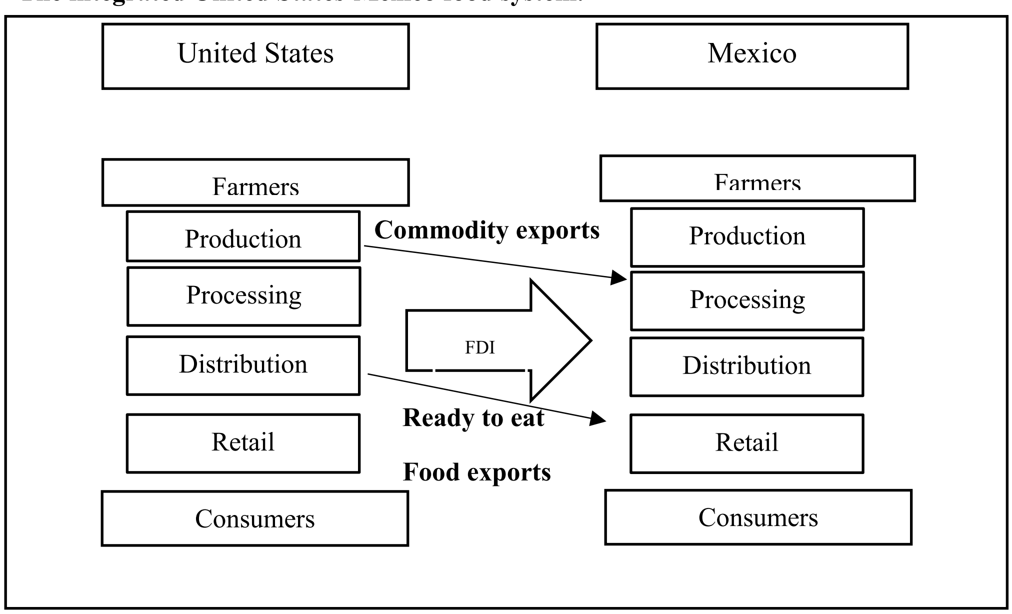
In the case of obesity, it is possible to observe an upward trend in every country in the sample, however this is not true in relation to the deaths attributed to CVDs or diabetes type 2. Only Brazil, Turkey and Mexico have easily observable trends in the comorbidities of obesity. It is also interesting to note that in the case of Colombia and Peru both have similar obesity rates and total deaths in relation to their population size. In the next subchapter the determinants facilitating the diet shifts that generate this trends will be assessed.

4.1 The world systems theory on the Mexican case.

The two main determinants of obesity that are recognized in the world systems theory are FDI flows in the food industry and food exports from global north countries to global south countries. This obeys to the idea that food choices are constraint by the economic and political systems. In this section these two topics are briefly discussed with an emphasis in the Mexican case.

In regard to the trade relation of the United States and Mexico, Corinna Hawkes (2005) points out that the latter attracted $5 Billion dollars of FDI in the food processing sector from the former in 1998, which was a 25-fold increase from $210 million in 1987 (Bolling et al., 1999), by 2000 Mexico was already a larger FDI recipient in the food sector than Canada (Mattson & Koo, 2002), specifically in products such as soft drinks, snacks and mayonnaise (Hawkes, 2005). Mexico has been greatly influenced by the agricultural and trade policy of the United States through two main forces: first, the increase of United States exports to Mexico of products linked to shifts in dietary patterns after the NAFTA agreement; second, the sizeable agribusiness investments coming from the United States throughout the whole Mexican food supply chain, with the outcome of making Mexico's food system increasingly similar to the United States industrialized food system.

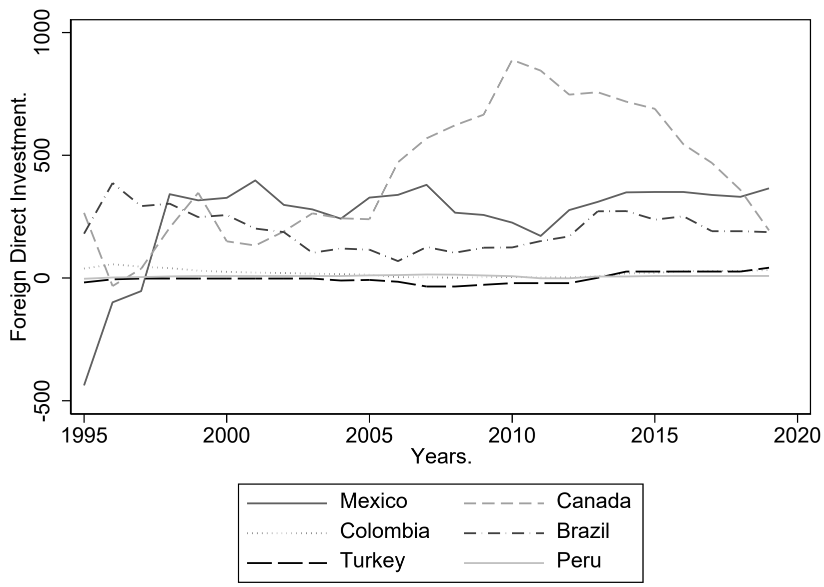
Figure 4.4- The integrated United States-Mexico food system.



Source: Adapted from Clark et al., 2012.

Making country level assessments for FDI flows is particularly difficult to do as countries often cannot report precise data by industry or investing country as cases where only one firm performed a major investment on a given year exists, therefore declaring the total amount of the investment would count as disclosing private information from a company. This is a common problem in the food industry, to counter it, this work uses a five-period moving average on the data disclosed by the Bureau of Economic Analysis of the United States which reports direct investments abroad on the food sector in millions of 2018 dollars.

Figure 4.5- Evolution of the United States FDI abroad on the food sector in millions of 2018 dollars in selected countries from 1995 to 2019.



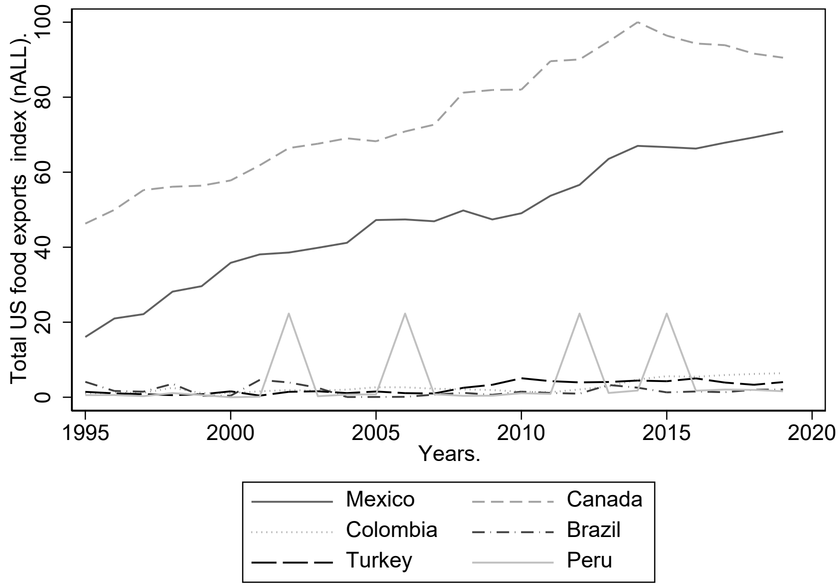
Source: Own elaboration with data from the U.S. Bureau of Economic Analysis using STATA 16.

FDI behavior on the food sector shifted in Mexico after 1995, from having net outflows to having net inflows, even surpassing those of Canada starting in 2000 and until 2006, this happeneed again in 2019 after the start of a downward trend that started in 2011 in Canada. The other countries do not present a lot of activity from the United States in the period except for Brazil which comes close to Mexico and Canada despite it not belonging to the NAFTA. It is relevant to remember that the acceleration of FDI growth in the Mexican food system was only possible due the sign of the NAFTA, which in turn reduced prices and increased food availability through trade and FDI. Some authors such as Baggio & Chong (2020) believe that it did this in such a dramatic way that it incentivized a change in demand from traditional foodstuffs to processed food. Giuntella et al. (2020) suggest that this could explain up to 20% of the total rise in obesity prevalence among Mexican women between 1988 and 2012 that can subsequently be correlated with the increase of obesity's comorbidities in Mexico.

For the analysis of the United States food exports to each of the countries sampled in this study, the USDA Foreign Agricultural Service (FAS) designation for Bulk, Intermediate & Consumer Oriented goods at a 6-digit level (BICO-HS6) is selected, this classification is usually used to compare aggregates of different categories of food imports and exports in the United States. As the information gathered from the FAS is very detailed, this work summarizes it with the use of principal component analysis (PCA) which is a way to create an index from a group of variables that are similar between them allowing to maximize the information used (it also avoids problems of multicollinearity when used in regressions). First correlations are tested to be high and significant (Table A.1) after that, the first components predicted that explain up to 90% of the cumulative variance of all the factors are selected. Table A.3 demonstrates the validity of performing a PCA for the data. Bartlett's test of sphericity null hypothesis that the dataset comes from a population in which the variables are noncollinear and that the non-zero correlations in the dataset are due to a sampling error is rejected, and the Kaiser-Meyer-Olkin (KMO) statistic proves to be higher than 0.90 which indicates that factor analysis of the variables is a plausible given the sample size of the data. Table A.4 displays that the 87.63 of the cumulative variances is explained by the first and second components, this also happens to meet the Kaiser criterion of being higher than 1 in the eigenvalues of every component selected, consequently two unrotated factors are generated. It is also valuable to mention that every variable used is in the same unit and therefore no scaling is necessary prior to its implementation.

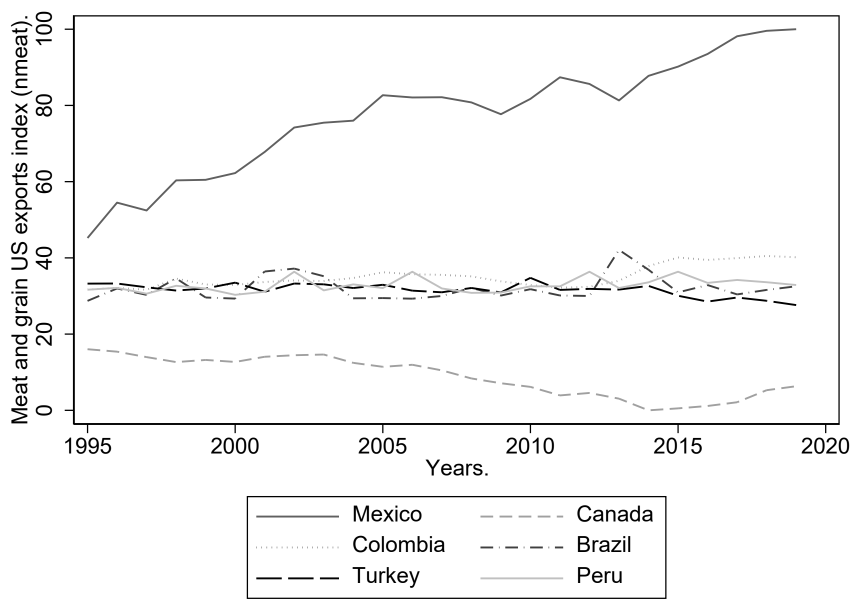
It can be noted that Table A.5 shows that every factor loading of factor 1 is positive with a higher value than 0.5 while *Procmeat, beef, dairy, pork, poultry, corn, rice, soybean,* and *wheat* have positive factor loadings in factor 2 with values higher than 0.45, these two factors are then generated through min-max rescaling into values between 0 and 1 and then multiplied by 100 to become an index. Another index is generated following this exact same method but for exports of alcoholic beverages, every step of the methodology can be seen at the appendix of this work, the resulting index is named *nAlcohol*. Figures 4.6 and 4.7 show the evolution of the behavior of the two exports indexes *nALL* for factor 1 and *nMeat* for factor 2, while Figure 4.8 does so for *nAlcohol*. It is observable than the evolution of the three groups of exports is different, while Canada is the country in the sample that receives more exports of alcoholic beverages and food overall, Mexico is the country that imports more meats and grains from the United States. This makes some authors such as Clark et al. (2012) conclude that exports from the United States to Mexico are one of the major factors that explain the shifts in the mexican dietary patterns of the last two decades given the link of these food groups with increasing obesity.

Figure 4.6- Evolution of the United States food exports to selected countries from 1995 to 2019.



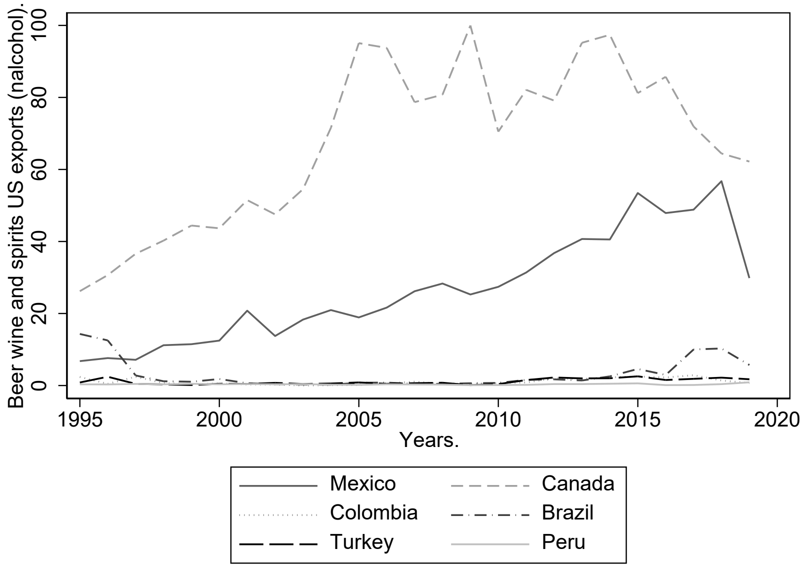
Source: Own elaboration using STATA 16.

Figure 4.7- Evolution of the United States meats and grain exports to selected countries from 1995 to 2019.



Source: Own elaboration using STATA 16.

Figure 4.8- Evolution of the United States beer, wine, and spirits exports to selected countries from 1995 to 2019.



Source: Own elaboration using STATA 16.

4.2 The modernization theory on the Mexican case.

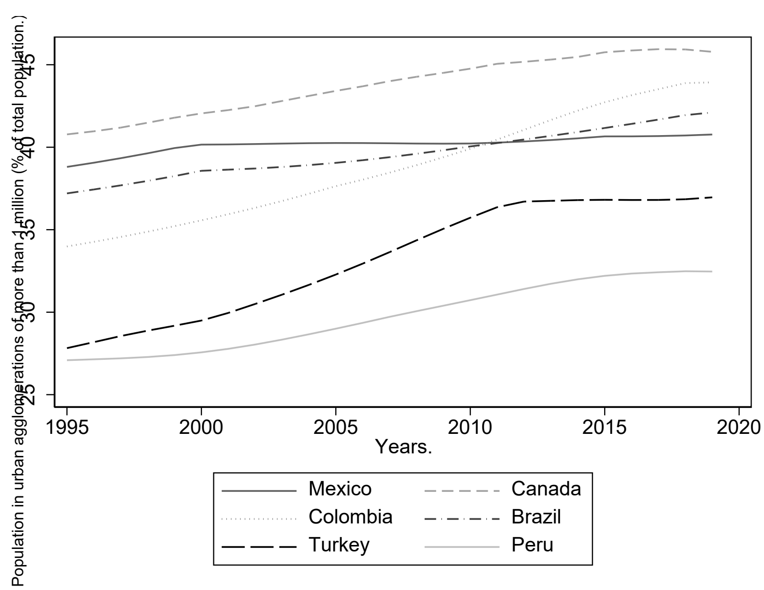
The notion behind the modernization theory is that economic development and economic growth lead to a series of changes that have consequences for human health, these changes occur in a specific technological context for different communities across history. Modernization can be understood as a process with stages; therefore, sometimes it might be difficult to discern modernization theory from the concept of nutritional transition that is inherently historical. In the context of the modernization theory literature that focuses on obesity and as a single explanation of modernization can't be extended then a single explanation for a general world nutritional transition is inconceivable. Nevertheless, the impacts of the nutrition transition in the last decades is undeniable, a higher income with higher food accessibility and variety combined with overall decreasing physical activity due to higher amounts of capital and technology produces an increase in obesity. In this section the main determinants of the modernization theory will be assessed with an emphasis in the Mexican case.

The determinants of the modernization theory emanate from economic development, this work identifies three sources for the determinants that are discussed within the theory of modernization, these sources are: urbanization, globalization-democratization and the poverty-growth-inequality triangle (An et al., 2020; Cuevas Garciá-Dorado et al., 2019; Fox et al., 2019), as the last two sources are broad categories composed of two or more concepts that produce direct effects on many observable variables such as the advancement of communication technologies and women's empowerment through economic rights the description of urbanization for the selected group of countries is presented first.

4.2.1 The impact of urbanization.

In Mexico, as in other upper middle-income countries, growth in urban areas has been paired with increasing growth in the services sector and in its job market during the last decades, which created an environment where workers not only perform less physical activity than workers in the primary and secondary sector, but according to some authors (Ortiz-Hernández et al., 2006; Rivera et al., 2002) due to the economy tertiarization workers also have disincentives to consume food prepared at home due to time constraints, while having incentives to consume diets higher in fat and proteins due to easy accessibility (Pineda et al., 2021). It is interesting to mention that in the Mexican case, Rivera et al. (2004) have shown that this obesogenic food environment is common among all socioeconomic groups in both rural and urban settings. However, Pérez-Tepayo et al. (2020) found that the lowest quality diets where located in households in urban environments, particularly where the head of the household were young males.

Figure 4.9- Evolution of the population living in urban agglomerations of more than 1 million people in selected countries from 1995 to 2019.



Source: Own elaboration with data from the United Nations Department of Economic and Social Affairs using STATA 16.

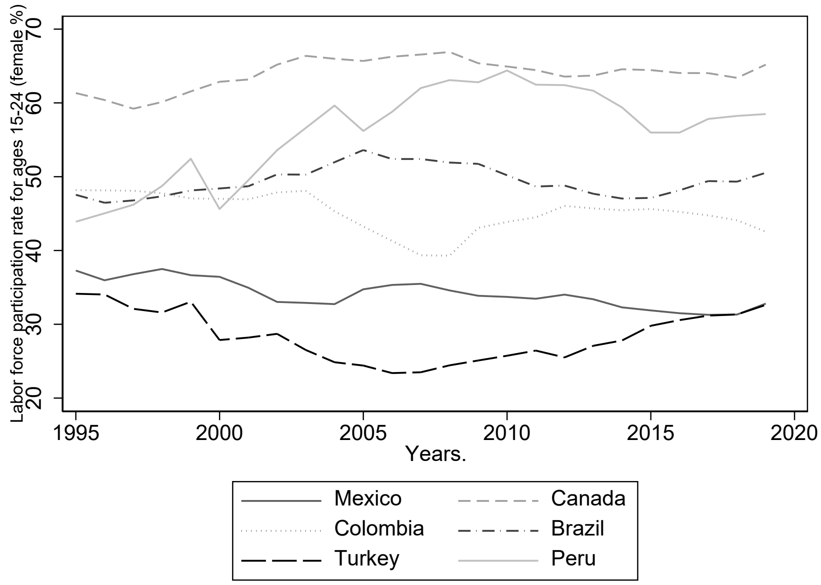
Figure 4.9 illustrates the evolution of the population living in urban agglomerations of over 1 million people, it can be noted that Mexico has been experiencing a growth that seemed to have stagnated after a peak in the year 2000, on the contrary, countries like Turkey, Colombia, and Brazil have not slowed down in their share of population living in big cities, even surpassing Mexico since 2011 in the case of Colombia and Brazil.

4.2.2 The impact of globalization and democratization.

The next set of variables are those that come from the globalization-democratization category, the first one being the influence of traditional and social media on a food demand at a country level, although advancements are being made, especially in social media such as Facebook, Instagram and TikTok but only at an individual level (Qutteina et al., 2019; Rodríguez-Pérez et al., 2020) no data is currently available. Another relevant concept is women's empowerment, even though different comprehensive indexes for all countries are made they are often non comparable or have missing values, the single most used index for this reason is the V-Dem index (Sundström et al., 2017) which provides information on women's political empowerment and contains information from 1900 to 2012 for 190 countries which comes with the major limitation of not including values until 2019, for this predicament Fox et al. (2019) suggests to use other variables such as the women's participation rate at the job market, additionally, expected years of schooling for the female population is also used in this work regardless being incomplete for the time period, these two variables are shown in figure 4.10 and 4.11. It is important to remark that these variables also come with their shortcomings in certain particular scenarios, for instance that women's participation in the labor force may be increasing but overall real minimum wages are decreasing in an economy, which does not translate in a higher level of women's empowerment as economic freedom is not increased, that is exactly the case that Ortiz-Hernández et al. (2006) identified for the Mexican women from 1980 to 2000.

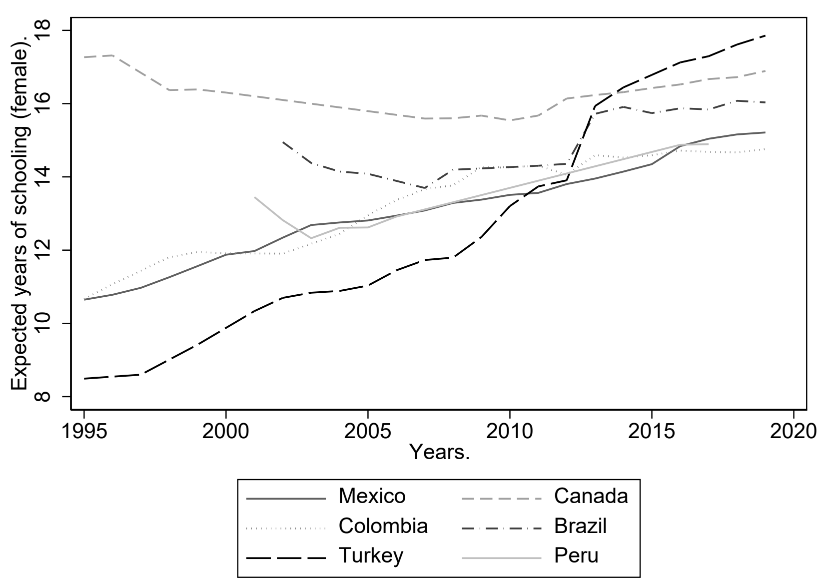
Canada has the highest percentage female labor participation rate for women from 15 to 24 years old, while Turkey has been the lowest for the period but has shown a recovering trend, unlike Mexico where increasing levels of violence towards women can be a potential factor to explain its downwards trend (Velasquez, 2020). In the case of years of schooling all the countries of the sample have upward trends with Turkey and Canada having the highest and the Latin-American countries the lowest. These two factors have different expected effects of obesity, the downward trend of the Mexican women on the labor force should have a decreasing effect on obesity while the contrary would be said about the upward trend on expected schooling years for females.

Figure 4.10- Evolution of the female labor force participation rate in selected countries from 1995 to 2019.



Source: Own elaboration with data from the International Labour Organization using STATA 16.

Figure 4.11- Evolution of women's expected years of schooling in selected countries from 1995 to 2019.



Source: Own elaboration with data from UNESCO using STATA 16.

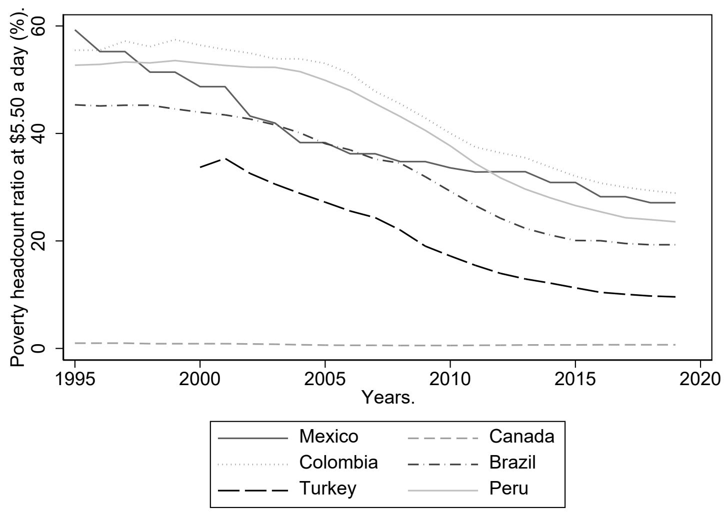
4.2.3 The impact of poverty, growth, and inequality.

The last set of variables is the one included in the poverty-growth-inequality triangle, it is relevant to mention that this concept developed by Bourguignon (2004) has not been found in the literature regarding the modernization theory or the nutrition transition during the literature review for the making of this work, and that is being used in this study as a way to name the three variables that compose it and that are recognized each individually to have effects on obesity and its comorbidities. These variables possess their own set of challenges to work with, although they are some of the most used variables in a vast quantity of studies about obesity and the nutritional transition (An et al., 2020; Cuevas Garciá-Dorado et al., 2019; Otero et al., 2018; Vogli et al., 2014), in the case of poverty and inequality they are often estimated by institutions and governments in a disperse fashion over the years which makes this work to use the same strategy presented for the FDI data in chapter 3.1 of using moving averages of five periods in order to obtain data that can be compared within the group of countries. Another complication in the case of poverty and inequality is that often the two concepts overlaps within studies and the effect of them cannot be separated, for example, for Otero et al. (2018) indicate that poverty and economic inequality restrict the food choices of households to low-cost food which may lead to obesity in the household, it was found out in their research that in the case of Mexico, sugar (in the form of soft drinks, candy, and sweet breads) was consumed more by the lowest income quintiles than by the other quintiles because of the high calories it contains despite it being nutritionally empty, but is not clear which of the individual effects leads to his conclusion as the idea of income inequality is introduced by the use of quintiles it is ultimately poverty which restricts the food choices of a household.

The set of variables is sourced from the World Bank. The poverty threshold that is being used in this work is $5.5 dollars of 2011 a day, the percentage of population under this line is used. For income inequality the preferred variable is the estimation of the Gini index. GDP per capita in 2017 dollars is also used along the GDP per capita growth rate computed as the natural logarithm differences of the GDP per capita.

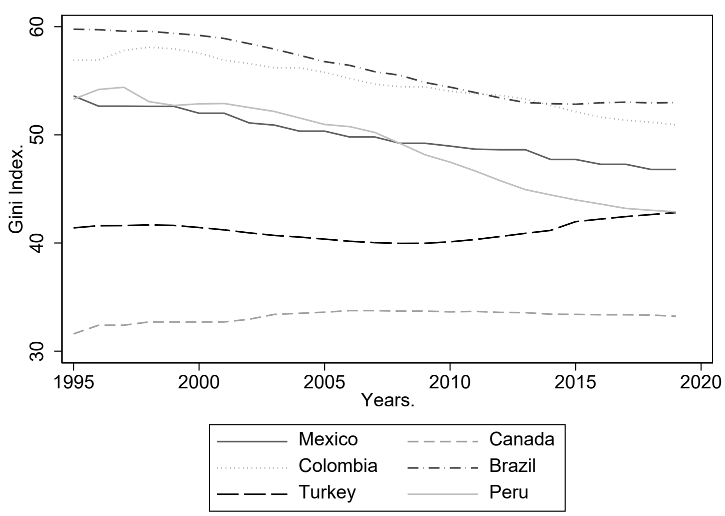
All the countries in the group show a downward trend for poverty, which is expected, Turkey have the lowest levels of poverty of the group while Colombia, Peru and Mexico have the highest, however Mexico's evolution is, showcasing a big poverty fall in the first years of the 2000s and then slowing from this fall from 2005 and onwards, at the point that Peru reported lower levels of poverty than Mexico by 2012. Inequality has been at constant decrease in the case of the Latin-American countries including Mexico contrary to Canada and Turkey that have slight increases in inequality, the country that shows the major decrease in inequality is Peru, but Canada still comes as the most equalitarian country. Turkey also appears to have positive macroeconomic performance as its GDP per capita outgrown Latin America in 2004 when it was at a lower level than Mexico in 1995, almost by the end of 2019 a recession occurred which caused a fall on turkey's GDP, total and per capita, it can be noticed that out of all the Latin-American countries Mexico seems to be the one with worst performance, although the performance of all of them has not been the stellar.

Figure 4.12– Evolution of the poverty headcount ratio at $5.50 a day in 2011 PPP dollars (% of population) in selected countries from 1995 to 2019.



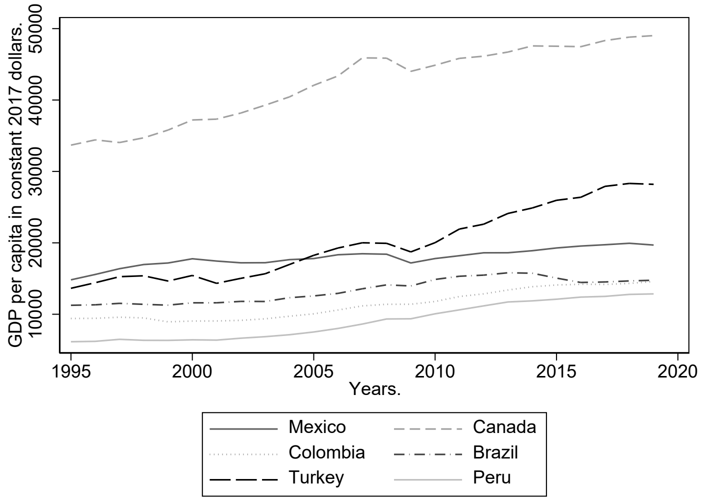
Source: Own elaboration with data from the World Bank (2021).

Figure 4.13- Evolution of the Gini index in selected countries from 1995 to 2019.



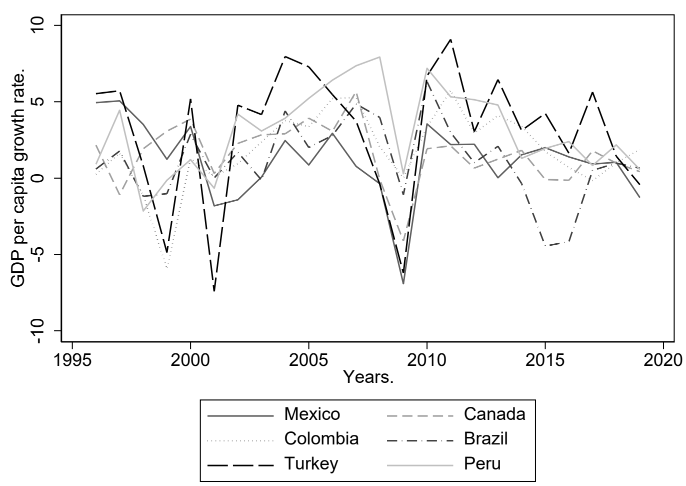
Source: Own elaboration with data from the World Bank (2021).

Figure 4.14- Evolution of the GDP per capita in 2017 PPP dollars in selected countries from 1995 to 2019.



Source: Own elaboration with data from the World Bank (2021).

Figure 4.15- Growth rates in selected countries from 1995 to 2019.

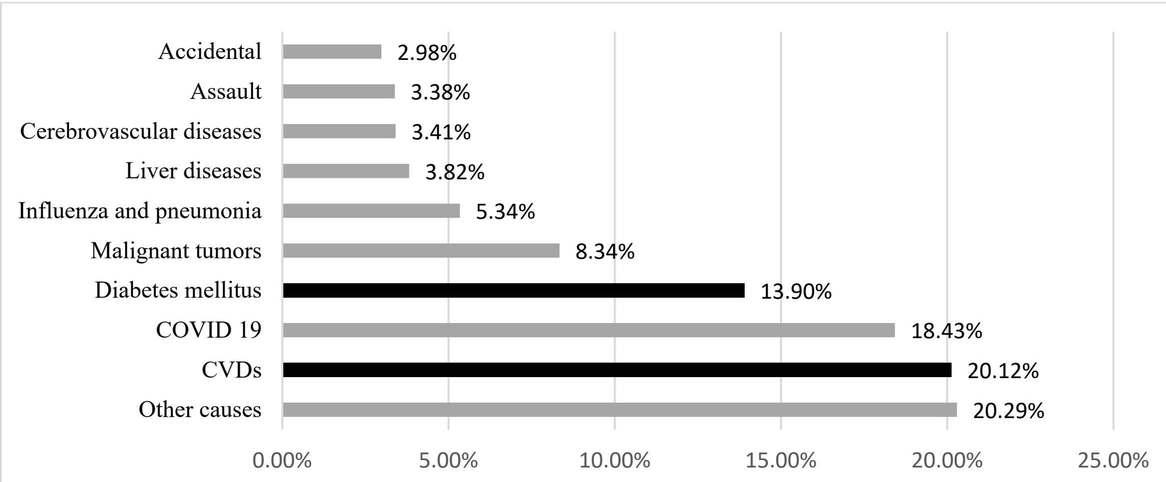


Source: Own elaboration with data from the World Bank (2021).

As it has been reviewed under chapter 2 and chapter 3, it has been established that various macroeconomic factors may induce changes in diets that have the potential to lead to increased mortality from obesity's comorbidities, during chapter 4, the impact of these determinants on the total deaths attributed to diabetes type 2 and cardiovascular diseases will be assessed through an econometric model.

5 Modeling the comorbidities of obesity using obesity determinants.

Figure 5.1- Main causes of death in Mexico in 2020.



Source: Own elaboration with data from INEGI. Dirección General de Estadísticas Sociodemográficas using Excel.

The aim of this chapter is to develop a model that can confirm the theoretical relation between the main determinants of obesity explored in the previous chapters and the two most common death causes linked to obesity in Mexico, CVDs, and diabetes. There are multiple models that make use of these theoretical determinants of obesity but also use proxy variables of obesity such as body fat percentage and BMI as the dependent variables (An et al., 2020; Cuevas Garciá-Dorado et al., 2019). This comes with the limitation that usually this kind of data comes from national surveys that do not offer a continuous series, like Fox et al. (2019). The way this work tries to overcome this issue is to use the deaths attributed to CVDs and diabetes as proxy variables to obesity taking advantage of the well-established relation between these variables.

5.1 Data and methodology.

The main issue for both the collection and processing of each individual variable has been explained in chapters 3.1 and 3.2. However, the descriptive statistics for these variables is offered for the first time in Table 5.1. A panel data is set with these variables for the countries selected for this study: Mexico, Canada, Colombia, Brazil, Turkey, and Peru with a time dimension of 25 (1995-2019).

The database used to build this database has been sourced from several online resources, both the total number of death cases from cardiovascular and diabetes type 2 is sourced from the Global Burden of Disease collaboration Network study from 2019 that the Institute for Health Metrics and Evaluation (IHME) coordinates, FDI coming from the United States into selected countries comes from the Bureau of Economic Analysis of the United States, the total food exports from the United States into the selected countries is referenced from the USDA Foreign Agricultural Service (FAS), urbanization rates from around the world is documented by the United Nations, World Urbanization prospects project, in other hand, the International Labor Organization presents information about labor force participation rates in the ILOSTAT database, the institute for statistics of UNESCO has a database with the average years of schooling for each country, per year and gender, data on poverty, inequality and economic growth was sourced from the World Bank.

Table 5.1- Summary statistics, imputed data.

	Number of obs.	Mean	Std. Dev.	min	max
T	150	2007	7.23	1995	2019
cvd	150	123150.66	102049.19	19653.23	397993.05
diabetes2	150	20229.18	19422.39	1916.65	72036.04
fdima5	150	148.94	206.80	-437.38	888.93
nMeat	150	.16	0.25	0	1
nALL	150	.18	0.27	0	1
nAlcohol	150	.17	0.27	0	1
urb	150	37.54	5.20	27.09	45.94
flabor	150	46.19	12.65	23.39	66.90
fschoolma5	150	14.05	1.74	9.51	17.19
povma5	150	28.02	16.47	.60	56.44
ginima5	150	47.35	8.32	31.60	59.76
gdppc	150	18981.03	11590.93	6154.17	49006.74

Source: Own elaboration using STATA 16.

Table 5.2- Description of variables presented in Table 4.1

Name	Description
T	Year.
obesity	Share of the adult population with of obesity in the adult population (18 years and older).
cvd	Deaths attributed to cardiovascular diseases.
diabetes2	Deaths attributed to diabetes type 2.
fdima5	5 period moving average of the foreign direct investments from the United States in the food sector.
nMeat	PCA generated variable rescaled and multiplied by 100 representing the export flows of dairy, meats and grains from the United States
nALL	PCA generated variable rescaled and multiplied by 100 representing all food exports from the United States.
nAlcohol	PCA generated variable rescaled and multiplied by 100 representing beer, spirits, and wine exports from the United States.
urb	Population in urban agglomerations of more than 1 million (% of total population).
flabor	Labor force participation rate for ages 15-24, female (%) (modeled ILO estimate).
fschoolma5	5 period moving average of women's expected years of schooling.
povma5	5 period moving average of the poverty headcount ratio at $5.50 a day.
ginima5	5 period moving average of the Gini index.
gdppc	Gross domestic product per capita.

Source: Own elaboration.

According to the two theories reviewed in this work the model that explains the deaths attributed to CVDs (*cvd*) or diabetes (*diabetes2*) would have the general linear form:

1. $$lnY_{it} = \beta_0 + \beta_1 nALL_{it} + \beta_2 nMeat_{it} + \beta_3 nAlcohol_{it} + \beta_4 Urb_{it} + \beta_5 ginima5_{it} + \beta_6 fdima5_{it} + \beta_7 povma5_{it} + \beta_8 lngdppc_{it} + \beta_9 fempowerment_{it} + Z_i + \varepsilon_{it}$$

Where Y_{it} is the number of deaths attributed to either CVDs or diabetes type 2 depending on the model. The independent variables listed in the model have the same codename that appears in Table 5.2. Z_i is the specific, time-invariant effect of country and ε_{it} is the random error term. It is important to mention that, as it was previously suggested, female empowerment ($fempowerment$) consists of both the labor force participation rate for women and women's expected years of schooling (*flabor and fschoolma5*).

The data used in the model is identified as non-stationary for the period of the sample (1995-2019) by the panel data unit root Im-Pesharan-Shin (IPS) test (2003) accounting for autocorrelation and a trend (A table with the results of the tests can be found in the appendix). The results of the test were expected given the large number of years that this study is working with. In this case a two-step panel error correction model (ECM) has been chosen as the most ideal option to work with this dataset as the sample is also cointegrated (Engle & Granger, 1987). ECMs need data that is cointegrated (that shares a stochastic trend) to estimate the effect (both on the short and on the long run) on another time series.

Although ECMs were created for time series analysis panel data tests were later developed (Persyn & Westerlund, 2008). As a next step, cointegration is tested by the Westerlund panel cointegration test (Westerlund, 2005) accounting for a trend and using the alternative hypothesis of cointegration in all panels (results can be found in Table 5.3), the null hypothesis of no cointegration is rejected.

Table 5.3- Westerlund cointegration test

Ho: No cointegration Number of panels = 6
Ha: All panels are cointegrated Number of periods = 25
Cointegrating vector: Panel specific
Panel means: Included
Time trend: Included
AR parameter: Same

Variables tested	Statistic	P-value
lcvd, nAll, nMeat, nAlcohol, Urb, ginima5, fdima5, lgdppc	2.1085	0.0175
ldiabetes2, nAll, nMeat, nAlcohol, Urb, ginima5, fdima5, lgdppc	3.2622	0.0006

Source: Own elaboration.

A limitation of the Westerlund cointegration test is that only six dependent variables can be tested at a time and therefore it is not possible to test for every possible variable recognized in the general form of the model above. However, when included, female empowerment variables and the poverty variable were proven not to be cointegrated with other variables and were consequently dropped from the model.

Once that non-stationarity and cointegration were tested for in each variable constituting the data panel, it is time to estimate the ECM model. In ECMs both long-term and short-term effects are estimated to describe how the dependent variable and the independent variables behave in the short run considering a long run cointegrated dynamic, to accomplish this a long run equation is created and its error is used in a difference-stationary equation that models the short run.

As a first step the long run equation is run through dynamic ordinary least squares (DOLS) (Stock & Watson, 1993), DOLS take care of the problem of endogeneity adding both the leads and lags of each variable into the regression, residuals u_{it} are then stored to be used in the second (short run) regression through OLS, using u_{it-1} as the error correction term or adjustment term along the first difference of the variables to obtain the short run results. The error correction term is expected to have a coefficient α that is a negative value between -1 and 0, which would point out to a long-run propensity towards an equilibrium relationship between every variable. An important consideration to make for the models is that of the term Z_i, as several non-observable variables may affect the comorbidities assessed in these models biased estimated effects are expected to be obtained. A solution to this problem is to use fixed effect estimators (the Hausman test (1978) that justifies the use of fixed effects can be found in the appendix section.).

Long run (Dynamic ordinary least squares with order 1)

2. $lnY_{it} = \beta_0 + \beta_1^{-1} nALL_{it-1} + \beta_1^{0} nALL_{it} + \beta_1^{+1} nALL_{it+1} + \beta_2^{-1} nMeat_{it-1} + \beta_2^{0} nMeat_{it} + \beta_2^{+1} nMeat_{it+1} + \beta_3^{-1} nAlcohol_{it-1} + \beta_3^{0} nAlcohol_{it} + \beta_3^{+1} nAlcohol_{it+1} + \beta_4^{-1} Urb_{it-1} + \beta_4^{0} Urb_{it} + \beta_4^{+1} Urb_{it+1} + \beta_5^{-1} ginima5_{it-1} + \beta_5^{0} ginima5_{it} + \beta_5^{+1} ginima5_{it+1} + \beta_6^{-1} fdima5_{it-1} + \beta_6^{0} fdima5_{it} + \beta_6^{+1} fdima5_{it+1} + +\beta_7^{-1} lngdppc_{it-1} + \beta_7^{0} lngdppc_{it} + \beta_7^{+1} lngdppc_{it+1} + u_{it} + \delta_{1t} + \delta_{2t} + \delta_{3t} + \delta_{4t} + \delta_{5t} + \delta_{6t}$

Short run (Two step equation in differences)

1. $\Delta lnY_{it} = \Delta\sigma_1 nALL_{it} + \Delta\sigma_2 nMeat_{it} + \Delta\sigma_3 nAlcohol_{it} + \Delta\sigma_4 Urb_{it} + \Delta\sigma_5 ginima5_{it} + \Delta\sigma_6 fdima5_{it} + \Delta\sigma_7 lngdppc_{it} + \alpha u_{it-1} + v_{it}$

Where Δ represent a first order difference in any dependent or independent variable. For example: $\Delta x = x_{it} - x_{it-1}$. The coefficients $\delta_{1t}, \delta_{2t}, \delta_{3t}$ ... δ_{6t} are specific time trends for each country in the sample, these coefficients do not appear in the short run equation along β_0 because the model is specified as a fixed effect model and therefore these coefficients are canceled out ($\beta_0 - \beta_0$ and $\delta_{1t} + \delta_{2t} + \delta_{3t} + \delta_{4t} + \delta_{5t} + \delta_{6t} - \delta_{1t-1} + \delta_{2t-1} + \delta_{3t-1} + \delta_{4t-1} + \delta_{5t-1} + \delta_{6t-1}$).

5.2 Results.

Table 5.4 and Table 5.5 show the regression coefficients and standard errors for each variable included in the two regressions, the one for diabetes type 2 and the one for CVDs for both the long run and the short run equations.

Table 5.4- Long run result from ECM.

	ldiabetes2	*lcvd*
L.nALL	**-.0024***	-.0003
	(.0014)	(.0009)
nALL	-.0012	-.0004
	(.0015)	(.0009)
F.nALL	-.001	-.0004
	(.0014)	(.0009)
L.nmeat	.0037	**-.003****
	(.0024)	**(.0015)**
nmeat	.0017	-.0015
	(.0029)	(.0018)
F.nmeat	.004	-.001
	(.0025)	(.0015)
L.nalcohol	.0016	.0004
	(.0012)	(.0008)
nalcohol	.0009	-.0003
	(.0012)	(.0007)
F.nalcohol	**.0024****	-.0001
	(.0009)	(.0006)
L.urb	**-.1867***	.0104
	(.1043)	(.0647)
urb	**.4054****	.1509
	(.1778)	(.1103)
F.urb	**-.1974****	**-.1573*****
	(.0919)	**(.057)**
L.ginima5	.0139	**-.0226****
	(.0181)	**(.0112)**
ginima5	-.0077	-.007
	(.0282)	(.0175)
F.ginima5	-.0205	.0046
	(.0209)	(.013)
L.fdima5	**-.0003*****	**-.0001***
	(.0001)	**(.0001)**
fdima5	0	0
	(.0001)	(.0001)
F.fdima5	0	0
	(.0001)	(.0001)
L.lgdppc	.2138	.1523
	(.2061)	(.1279)
lgdppc	-.2663	-.1802
	(.2698)	(.1674)
F.lgdppc	-.001	.033
	(.2002)	(.1242)
t1	.0185**	.0379***
	(.0086)	(.0053)

t2	.0081	-.002
	(.0083)	(.0051)
t3	-.0098	.0101*
	(.0086)	(.0053)
t4	.0208***	.0034
	(.0046)	(.0029)
t5	.0137	.0129*
	(.0114)	(.0071)
t6	.0308***	.0013
	(.007)	(.0044)
_cons	9.334***	12.5288***
	(1.9825)	(1.2301)
Observations	138	138
R-squared	.9396	.9488

Standard errors are in parentheses
**** p<.01, ** p<.05, * p<.1*
F. is the time series operator for Lead x_{it+1}
L. is the time series operator for Lag x_{it-1}

Source. Own elaboration.

Table 5.4- Short run result from ECM.

	D.ldiabetes2	D.lcvd
D.nALL	-.0004	-.0001
	(.0005)	(.0004)
D.nmeat	.0011	-.0001
	(.0011)	(.0009)
D.nalcohol	-.0005	-.0005
	(.0004)	(.0003)
D.urb	.0233	-.0034
	(.0187)	(.0147)
D.ginima5	-.0151	**-.0179****
	(.0093)	**(.0074)**
D.fdima5	**-.0001****	0
	(0)	(0)
D.lgdppc	**-.2513*****	**-.1804****
	(.0903)	**(.0713)**
L.ecmd	**-.1883*****	
	(.0516)	
L.ecmc		**-.2624*****
		(.0657)
Observations	138	138
R-squared	.2096	.2217

Standard errors are in parentheses
**** p<.01, ** p<.05, * p<.1*
L. is the time series operator for Lag x_{it-1}
D. is the time series operators for first difference $\Delta x = x_{it} - x_{it-1}$.

Source. Own elaboration.

The results found in the long run equations reflect the long-run association between the number of deaths caused by CVDs and diabetes type 2 with the variables used in the model while considering the effect of time on both the dependent and independent variables. Surprisingly results did not indicate any sort of association between any of the specific categories of food exports from the United States to the countries in the sample. In the short run, urbanization was not found to be related to the dependent variable used in both models, however the two models demonstrate to possess different dynamics regarding FDI and income inequality. FDI seems to be inversely related to the numbers of deaths attributed to diabetes type 2 but not to the deaths attributed to CVDs, nevertheless the magnitude of the coefficient is too low to be considered as a concern factor in the short run (one year after the present one). In other hand, income inequality seems to have an inverse relation to the number of deaths attributed to CVDs, which can be interpreted as, the higher the magnitude of the Gini index then a relative larger number of people may experience worse socioeconomic conditions which in turn may lead them to a lower possibility of accessing good quality healthcare and in general to a bad quality of life with high amounts of stress. Both models have significant negative effects from the increase GDP per capita which is also consistent with theory. It is also worth to be aware that alternative specifications were performed to check robustness of the obtained results which yields greater confidence of the results showed.

Results were unexpected due to the weight that the world systems theory places on the food exports and FDI from developed countries to developing countries. Food exports prove not to be an important factor and FDI was expected to play a much more important role on health outcomes. The results favor modernization theory and set a foundation for more research towards this specific theory which is promising.

6 Discussion.

Two theories were assessed in this work, modernization theory assumes that society advances in a series of steps towards economic development, steps that are different in the context of each community, but that lead to nutrition transitions which, in the last decades have led to a specific form of nutrition transition that in combination with globalization, democratization, urbanization and the other dynamics conduct society into weight gain and chronic diseases. By contrast, the world systems theory attributes rising obesity to structural variables that developing countries have little control over and that create obesogenic food environments which results in higher rates of health conditions.

Using a panel dataset for a group of countries for a period of 25 years this study found that despite the previously mentioned world systems theory literature which suggests that FDI and food export flows from developed countries to developing countries generate obesogenic food environments statistical evidence from this study indicates otherwise in the short run, although this result is surprising similar studies that make use of other statistical tools (but applied to much more micro settings) point out to a direct relation between trade openness and positive health outcomes, for example, De Soysa & De Soysa (2018) in a study for 180 countries covering a time period from 1990 to 2013 indicate that trade openness and economic globalization reduce obesity rates only among the younger population which is a variable that this study did not cover, however, Oberlander et al. (2017) found that because trade openness increases the supply of animal protein and sugars it impacts society's overall health in a negative way, mentioning this, it is important to remember that this study found no relation between the increase of food exports and the increase of deaths related to CVDs or type 2 diabetes. It should be noted it can't be ruled out that these variables have different effects in the long run however income inequality proved to have an effect at least in one of the two models that this work proposes.

Other studies have not only accounted for age groups but also for income groups and have included control variables for both rural and urban areas, Nandi et al. (2014) concluded that FDI was associated with a higher overweight rates at a community level and that this was especially true for rural men which is something that is documented in theory and is not integrated into this work. Some studies like Estimé et al. (2014) have mixed results for different countries, in that study it was found that every country in the paper reported a significant relation between food imports and obesity, however the countries in the study were small islands with a small production of food, being Samoa the most famous case of obesity caused by food imports.

In the whole literature, just a small batch of studies make an effort to integrate both theories, being the most recent and prominent the one of Fox et al. (2019) where a dataset of 190 countries is used to create an econometric model, Fox et al. evidence demonstrated that increases of women's empowerment, urbanization and GDP per capita is associated with increases of mean BMI but did not found that economic globalization had an impact on mean BMI over time, with this, Fox et al. conclude that global increases of obesity are driven by domestic processes including economic development, urbanization and women's empowerment and are less clearly impacted by external factors. The results presented in this study seem to favor Fox et al. results while complementing that this is also true for the negative health outcomes associated with obesity.

A particular finding that is relevant is the documented relation between economic inequality and deaths attributed to CVDs, as previously mentioned this can be interpreted as worse socioeconomic conditions may in turn to a lower possibility of accessing good quality healthcare and in general to a bad quality of life with high amounts of stress, there is a also another reading that Otero et al. (2018) proposes with their findings, and it is that inequality is actually a direct driver of obesity because with higher inequality a relative higher population not only fails to access to quality healthcare but also quality food, however this would have also been reflected in the type 2 diabetes model.

The initial idea and concept behind this work was to check for existence of an impact from FDI and food exports from developed countries into developing ones, more specifically the idea was to prove if the increase of trade relations between Mexico and the United States since 1994 had an impact on Mexico's obesity rates, this was troublesome given that obesity rates at country level are not estimated every year. The normal solution to the problem of data scarcity is to use a variable of BMI as a proxy to obesity, which comes with its own problems (Parks et al., 2011) but is never the best alternative at a macro level or when other data is available (insulin resistance, blood pressure or waist circumference, as suggested by Parks et al. in 2011). The workaround that shaped this research was to look at the effects of obesity and use them as a proxy, the selected approach was to use the deaths caused by diseases that had a proven and documented relation with obesity and that also had plenty of additional data, as a matter of fact, this may be the best contribution that this work makes, the use of nontraditional variables to the study of obesity at a macroeconomic level.

However, the limitations of this work mean that the results of this study must be taken with some caution. First, this study is presented at a macro level and while this can be positive it also can hide the inside mechanisms in which the variables work. The main issue with the econometrical tool that is recommended in this analysis is that cointegrations tests can only prove relations of cointegration for a small number of variables. Another important point is that the quality of the macroeconomic data used for this model is not optimal and requires extra processing in the form of data imputation with moving averages which may have affected the results which were surprising, especially in the case of the effects of food exports from the United States in the short run. Nevertheless, this work takes a different approach in using non-orthodox dependent variables for a large period of time while combining this approach with a category of model that accounts for non-stationary time series which results in the possibility to compare two different theories at both the short and long run.

Given that conclusions can only be made about the short run, the key variables that this work identifies to be related with deaths caused by the comorbidities of obesity are income inequality and income growth, however these variables are broadly defined and more research should be made on the potential effects that income growth and its distribution have on obesity, focusing on their consequences as the effect of macroeconomic policies on income distribution is not clear. Nonetheless, an important policy implication can be extracted from the results of this work that can also be interesting to explore in future efforts. This hint don't come from the important and significant identified variables in the regression analysis but rather from both the impact of the FDI from the United States in the food sector and the exports from this country into the selected countries of this work, the connotation of this results is that the power of the world systems theory in the context of the countries selected for this work (upper middle-income economies and Canada) is low and that the factors related to economic development recognized in the modernization theory seem to have a higher impact on obesity and its effects, in this sense, if the desired result of policy makers is to reduce the amount of deaths related to obesity then the answer is not to reduce imports of foods or restrict FDI but to generate conditions for development, however it is important to say that this may be different in the case of other developing countries with lower levels of income as more research is needed to assure this.

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Annex.

Table A.1- Correlation Matrix of the different United States food exports according to designation BICO-HS6 in selected countries from 1995 to 2019.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
(1) bakcerpas	1.0																							
(2) candy	1.0*	1.0																						
(3) choc	1.0*	1.0*	1.0																					
(4) cond	1.0*	1.0*	1.0*	1.0																				
(5) procmeat	0.3*	0.3*	0.5*	0.4*	1.0																			
(6) softdrinks	1.0*	1.0*	1.0*	1.0*	0.3*	1.0																		
(7) procfruit	1.0*	1.0*	1.0*	1.0*	0.3*	1.0*	1.0																	
(8) procveg	0.9*	0.9*	1.0*	1.0*	0.5*	0.9*	1.0*	1.0																
(9) juices	0.9*	0.9*	0.9*	0.8*	0.1	0.9*	0.9*	0.8*	1.0															
(10) peanuts	0.8*	0.9*	0.9*	0.9*	0.6*	0.8*	0.9*	0.9*	0.7*	1.0														
(11) nuts	0.8*	0.8*	0.8*	0.9*	0.4*	0.8*	0.8*	0.8*	0.7*	0.7*	1.0													
(12) beef	0.5*	0.5*	0.7*	0.5*	0.9*	0.5*	0.5*	0.7*	0.4*	0.7*	0.5*	1.0												
(13) dairy	0.4*	0.4*	0.5*	0.5*	0.9*	0.4*	0.4*	0.6*	0.2*	0.7*	0.4*	0.8*	1.0											
(14) eggs	0.7*	0.8*	0.8*	0.7*	0.4*	0.7*	0.8*	0.8*	0.7*	0.8*	0.6*	0.6*	0.6*	1.0										
(15) pork	0.3*	0.3*	0.5*	0.4*	0.8*	0.3*	0.4*	0.6*	0.2*	0.7*	0.4*	0.8*	0.9*	0.6*	1.0									
(16) poultry	0.2*	0.2*	0.4*	0.3*	0.8*	0.2*	0.3*	0.5*	0.1	0.6*	0.4*	0.8*	0.9*	0.5*	1.0*	1.0								
(17) seafood	0.9*	1.0*	0.9*	0.9*	0.3*	0.9*	0.9*	0.9*	0.9*	0.8*	0.7*	0.5*	0.3*	0.8*	0.3*	0.2*	1.0							
(18) fruit	0.9*	1.0*	1.0*	0.9*	0.5*	0.9*	0.9*	0.9*	0.9*	0.9*	0.7*	0.7*	0.5*	0.9*	0.5*	0.4*	1.0*	1.0						
(19) veg	0.9*	1.0*	0.9*	0.9*	0.2*	0.9*	0.9*	0.9*	1.0*	0.8*	0.7*	0.5*	0.3*	0.8*	0.2*	0.2*	1.0*	1.0*	1.0					
(20) soup	0.1	0.2*	0.3*	0.1	0.4*	0.1	0.2*	0.2*	0.2	0.3*	0.1	0.5*	0.4*	0.3*	0.4*	0.4*	0.2*	0.3*	0.2*	1.0				
(21) corn	0.1	0.1	0.2*	0.2*	0.8*	0.1	0.1	0.4*	0.0	0.5*	0.2*	0.7*	0.8*	0.4*	0.9*	0.9*	0.1	0.3*	0.0	0.4*	1.0			
(22) rice	0.2*	0.2*	0.4*	0.3*	0.9*	0.2*	0.2*	0.5*	0.1	0.5*	0.3*	0.8*	0.9*	0.4*	0.9*	0.9*	0.2*	0.4*	0.1	0.4*	0.8*	1.0		
(23) soybean	0.0	0.1	0.2*	0.1	0.9*	0.1	0.1	0.3*	-0.1	0.4*	0.2*	0.8*	0.8*	0.3*	0.8*	0.9*	0.0	0.2*	0.0	0.4*	0.9*	0.9*	1.0	
(24) wheat	-0.2*	-0.1	0.0	0.0	0.8*	-0.1	-0.1	0.1	-0.3*	0.2*	0.0 1	0.6*	0.7*	0.1	0.7*	0.8*	-0.2*	0.0	-0.2*	0.4*	0.8*	0.7*	0.8*	1.0

* $p<0.1$

Source: Own elaboration with data from the USDA Foreign Agricultural Service, and a STATA program written by Shah (2018).

Table A.2- Description of variables presented in Table A.1.

Name	Description
bakcerpas	Bakery goods, cereals, and pasta.
beef	Beef and beef products.
candy	Chewing gum and candy.
choc	Chocolate and cocoa products.
cond	Condiments and sauces.
corn	Corn (maize) other than seed.
dairy	Dairy products.
eggs	Eggs and products.
fruit	Fresh fruits.
juices	Fruit and vegetable juices.
nuts	Tree nuts.
peanuts	Peanuts.
pork	Pork and pork products.
poultry	Poultry meat and products (excluding eggs).
procfruit	Processed fruit.
procmeat	Meat products.
procveg	Processed vegetables.
rice	Rice.
seafood	Seafood and fish.
softdrinks	Non-alcoholic beverages excluding tea, coffee, and juices.
soup	Soup and other food preparations.
soybean	Soya beans.
veg	Fresh vegetables.
wheat	Wheat.

Source: Own elaboration.

Table A.3- Bartlett's test of sphericity and Kaiser-Meyer-Olkin measure of sampling adequacy.

Statistic	Value
Determinant of the correlation matrix	0.000
Chi-square	9471.827
Degrees of freedom	276
p-value	0.000
KMO	0.926

Source: Own elaboration.

Table A.4- Principal component analysis.

Factor analysis/correlation		Number of observation =	146
Method: principal-component factors		Retained factors =	2
Rotation: (unrotated)		Number of params =	47

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	14.493	7.955	0.604	0.604
Factor2	6.538	5.628	0.272	0.876
Factor3	0.910	0.363	0.038	0.914
Factor4	0.546	0.153	0.023	0.937
Factor5	0.394	0.145	0.016	0.953
Factor6	0.249	0.051	0.010	0.964
Factor7	0.198	0.060	0.008	0.972
Factor8	0.138	0.027	0.006	0.978
Factor9	0.111	0.007	0.005	0.982
Factor10	0.105	0.014	0.004	0.987
Factor11	0.091	0.023	0.004	0.991
Factor12	0.068	0.024	0.003	0.993
Factor13	0.044	0.010	0.002	0.995
Factor14	0.034	0.014	0.001	0.997
Factor15	0.020	0.002	0.001	0.998
Factor16	0.018	0.007	0.001	0.998
Factor17	0.011	0.002	0.001	0.999
Factor18	0.009	0.002	0.000	0.999
Factor19	0.007	0.002	0.000	0.999
Factor20	0.005	0.002	0.000	1.000
Factor21	0.004	0.001	0.000	1.000
Factor22	0.003	0.000	0.000	1.000
Factor23	0.002	0.001	0.000	1.000
Factor24	0.002	.	0.000	1.000

LR test: independent vs. saturated: chi2(276) = 9541.39 Prob>chi2 = 0.0000

Source: Own elaboration.

Table A.5- Factor loadings and unique variances.

Variable	Factor1	Factor2	Uniqueness
bakcerpas	0.886	-0.438	0.024
candy	0.906	-0.407	0.013
choc	0.957	-0.236	0.029
cond	0.916	-0.303	0.070
procmeat	0.631	0.700	0.112
softdrinks	0.885	-0.390	0.065
procfruit	0.923	-0.360	0.019
procveg	0.983	-0.120	0.019
juices	0.800	-0.518	0.091
peanuts	0.959	0.030	0.080
nuts	0.800	-0.224	0.310
beef	0.784	0.493	0.143
dairy	0.717	0.637	0.081
eggs	0.856	-0.055	0.264
pork	0.670	0.675	0.096
poultry	0.610	0.738	0.083
seafood	0.865	-0.427	0.069
fruit	0.956	-0.216	0.039
veg	0.856	-0.471	0.045
soup	0.321	0.343	0.779
corn	0.468	0.801	0.139
rice	0.552	0.751	0.131
soybean	0.425	0.853	0.092
wheat	0.224	0.879	0.177

Source: Own elaboration.

Table A.6- Correlation Matrix of the different United States alcoholic beverage exports according to designation BICO-HS6 in selected countries from 1995 to 2019.

Variables	(1)	(2)	(3)
(1) *beer*	1.000		
(2) *wine*	0.480*	1.000	
	(0.000)		
(3) *spirits*	0.543*	0.866*	1.000
	(0.000)	(0.000)	

**** p<0.01, ** p<0.05, * p<0.1*

Source: Own elaboration with data from the USDA Foreign Agricultural Service, and a STATA program written by Shah (2018).

Table A.7- Bartlett's test of sphericity and Kaiser-Meyer-Olkin measure of sampling adequacy.

Statistic	Value
Determinant of the correlation matrix	0.176
Chi-square	255.299
Degrees of freedom	3
p-value	0.000
KMO	0.627

Source: Own elaboration.

Table A.8- Principal component analysis.

(obs=150)
Factor analysis/correlation Number of obs = 150
Method: principal-component factors Retained factors = 1
Rotation: (unrotated) Number of params = 3

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	2.276	1.683	0.759	0.759
Factor2	0.593	0.462	0.198	0.956
Factor3	0.131	.	0.044	1.000

LR test: independent vs. saturated: chi2(3) = 257.03 Prob>chi2 = 0.0000
Factor loadings (pattern matrix) and unique variances
Source: Own elaboration.

Table A.9- Factor loadings and unique variances.

Variable	Factor1	Uniqueness
beer	0.744	0.446
wine	0.917	0.159
spirits	0.939	0.118

Source: Own elaboration.

Table A.10- IPS test results.

Ho: All panels contain unit roots
Number of panels = 6
Ha: Some panels are stationary
Number of periods = 25
AR parameter: Panel-specific
Asymptotics: T,N -> Infinity
Panel means: Included
sequentially
ADF regressions: 1 lag

Variable	p-value	Time trend
lcvd	0.9614	Included
ldiabetes2	0.3349	Included
nALL	0.1833	Included
nMeat	0.2340	Included
lgdppc	0.4894	Included
Urb	0.5362	Included
Fdima5	0.8379	Included
Ginima5	0.2770	Included
nAlcohol	0.0534	Included
fschoolma5	0.7064	Included
flabor	0.1458	Not included

Source: Own elaboration.

Table A.11 Hausman (1978) specification test Fixed effects versus Random effects using *ldiabetes2* as the dependent variable.

	Coef.
Chi-square test value	101.52
P-value	0.000

Ho: difference in coefficients not systematic

Source: Own elaboration.

Table A.12 Hausman (1978) specification test Fixed effects versus Random effects using *lcvd* as the dependent variable.

	Coef.
Chi-square test value	107.14
P-value	0.000

Ho: difference in coefficients not systematic

Source: Own elaboration.