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Faculté des bioingénieurs

Trade Openness and the Triple Burden of Malnutrition

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Academic year 2021-2022
In partial fulfilment of the requirements for the degree of "Master of Science": Agricultural, Food, and Environmental Policy Analysis (AFEPA)

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Acknowledgements

First and foremost, I want to thank my first supervisor, Prof. Dr. Goedele Van den Broeck, for her encouragement and support. I always looked forward to our biweekly meetings and your feedback and support, which ensured that my thesis proceeded along easily and without delay. I would also like to thank my second supervisor, Dr. Yaghoob Jafari, for his willingness and availability to comment on my study with interesting questions and valuable ideas. I am also thankful to Prof Frederic Gaspart for his assistance during my econometric analysis. My appreciation also goes to Laura Enthoven for her assistance and continued support throughout the process of developing, reviewing, and completing my thesis.

Scholarship offers are quite competitive; therefore, I gratefully acknowledge the significant funding provided by the European Commission's Erasmus+ AFEPA program. The program also involved courses and therefore, I appreciate the insightful contributions of all course lecturers.

Finally, I am immensely thankful to my family for their unending love, support, and encouragement.

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List of Abbreviations

Acronyms	Definition
%	Percent
2SLS	Two Stage Least Squares
BMI	Body Mass Index
CV	Control variables
EM-DAT	Emergency Events Database
FAO	Food and Agriculture Organization
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Statistics
FE	Fixed Effects
FNS	Food and Nutrition Security
GDP	Gross Domestic Product
GFS	Global Food Systems
GMM	Generalized Methods of Moment
HI	High-income
HLPE	High Level Panel of Experts
IV	Instrumental Variable
LFS	Local Food Systems
LI	Low-income
LM	Lagrange multiplier
LMI	Lower middle-income
LMICs	Low-and-middle-income countries
OECD	Organisation for Economic Co-operation and Development
PoA	Prevalence of Anaemia among pregnant women
PoO	Prevalence of Obesity among adults
PoU	Prevalence of Undernourishment
PRIO	Peace Research Institute Oslo
RE	Random Effects
SDG	Sustainable Development Goal
SITC	Standard International Trade Classification
SSA	Sub-Saharan Africa
UMI	Upper middle-income
UN	United Nations
UNICEF	United Nations International Children's Emergency Fund
UNU	United Nations University
US	United States
USD	United States Dollar
WDI	World Development Indicators
WHO	World Health Organization
WTO	World Trade Organization

1.0 Introduction

The world population has increased from 3 billion in 1960 to around 7.5 billion today, and global food production has increased by more than 45 per cent, resulting in more food per person at lower prices (Brooks & Blandford, 2019). Over many years, food systems across the world have achieved great strides in reducing hunger, and are projected to ensure food and nutrition security for a population that is estimated to surpass 10 billion by the mid-century. However, our food systems today have key interconnected weaknesses that are driving today's nutrition crisis and limiting their ability to produce sustainable, nutritious meals for everyone, and achieve food security (Global Panel on Agriculture and Food Systems for Nutrition., 2020). It is not enough to provide food for people anymore; nutritious food that supports a healthy lifestyle must be supplied. Unfortunately, given the rising prevalence of malnutrition in every region of the world, current systems are unable to provide these basic requirements (Micha et al., 2020). In 2022, it was reported that as many as 828 million people faced hunger, around 3.1 billion people are unable to afford healthy diets, and 675.7 million adults are obese (FAO et al., 2022). Malnutrition is believed to be exacerbated by poverty, climate-related disasters, unhealthy eating habits, globalization, economic development and income growth, trade liberalization, COVID-19, and more recently the Russia-Ukraine War (FAO et al., 2022; OECD, 2021; Reardon et al., 2019).

Sustainable, inclusive and healthy food systems are being promoted as a major impact pathway for improving nutrition (G. Carletto et al., 2015). Yet, how to achieve this is under fierce policy and scientific debate, with a particularly strong discussion on the role of trade and the scale at which food systems should operate (Martin, 2018). Global food systems, on the one hand, characterized by trade liberalization and trade openness, are often promoted as they allow countries to exploit their comparative advantage (Anderson, 2010). Trade is believed to have the potential to enhance food access through raising Gross Domestic Product (GDP), per capita income, and financing for social safety net programs (Qaim, 2017). Furthermore, nations' reliance on international food trade has been linked to agricultural intensification, which has resulted in significant increases in crop output levels and decreased food prices (Evenson & Gollin, 2003). However, a country's heavy dependence on a few export goods to generate the foreign exchange required to fund food imports may leave it susceptible to changing economic conditions and shocks (Rutten et al., 2013). Also, when confronted with imminent food shortages or sharp price increase, governments in developing economies believe that the heavy agricultural subsidy policies in industrialized countries distorts trade, particularly their exports, hence they implement protective trade policies. However, some of the protective policies have backfired, leading to increases in domestic price and domestic price volatility (Porteous, 2017; Smith & Glauber, 2020). Local food systems, characterized by high levels of food self-sufficiency, have been put forward as low-and-middle-income countries (LMICs) are not always competitive enough to take advantage of agricultural trade liberalization (De Schutter, 2017; Mary, 2019). Trade policies are therefore considered strategic to shape food systems and promote food security (Marson et al., 2022).

There is a large body of literature on the effects of trade on poverty (Winters et al., 2004; Winters & Martuscelli, 2014), but the nutritional implications of trade are much less studied, and the few available empirical studies provide mixed evidence. More specifically, there are two main gaps in the literature. First, studies on the nutritional implications of food trade tend to focus on a single aspect of nutrition (usually calorie supply), thereby ignoring that malnutrition comprises undernourishment, micronutrient deficiencies and obesity. Second, they do not distinguish sufficiently between global and local food trade, nor between different agri-food product categories. This knowledge gap has given rise to three research questions investigated in this thesis: What is the impact of agricultural trade openness on the prevalence of undernourishment, micronutrient deficiencies and obesity? Is this impact different across trade in specific agri-food products? Is this impact different across low-, middle-, and high-income countries?

The three questions are addressed using econometric techniques and taking inspiration from recent literature. New empirical evidence based on a panel dataset of 114 countries from 2001 to 2018 is provided that contributes to the literature in three ways. First, for the global sample of countries, the impact of total agricultural trade openness on the prevalence of undernourishment (PoU), prevalence of anaemia among pregnant women (PoA), and prevalence of obesity among adults (PoO) is estimated. Second, emphasis is placed on agri-food product trade, notably cereals, fresh fruits and vegetables, and tropical commodities trade. The importance of focusing on cereals trade is based on the relevance of staple food in the overall calorie intake as well as in food trade (Brooks & Matthews, 2015; Traverso & Schiavo, 2020; Wright, 2012) and in related restrictions, as shown by the centrality of cereals in recent export bans (Porteous, 2017). The rationale for choosing tropical commodities and fresh fruits and vegetables trade is due to the drastic change and substantial increase in South-South trade and a shift in LMICs' exports from tropical commodities to high-value produce (Van den Broeck & Maertens, 2016). Thirdly, the analysis concentrated on the sub-sample income groups: High income (HI), Upper middle income (UMI), Lower middle income (LMI), and Low-income countries (LI). This categorization will allow me to capture the intrinsic distinctions across income groups.

The remainder of the thesis is organized as follows: Chapter 2 theorizes the likely positive and negative implications of trade on the dimensions of food security using existing macro and micro studies. Chapter 3 describes the data and methods used to analyze the research questions. Chapter 4 presents the empirical results and discussion, while Chapter 5 concludes and presents policy implications.

2.0 Literature review

This section provides an overview of the literature on the food systems and the nutrition transition, food (in)security and the triple burden of malnutrition, and the impact of trade on the dimensions of food security. Trade-food security ties have spurred a heated debate at both the national and global levels, and they have been central to many trade-related discussions and agreements. Some of the disagreement over the links between trade and food security can be traced back to their numerous definitions, dimensions and potential indicators. Hence, in the following section, a review of the existing literature outlining these concepts is put forward.

2.1 Food Systems

Food systems have been referred to as "the entire set of actors and their interconnected value-added activities involved in the production, aggregation, processing, distribution, consumption, and disposal of food products derived from agriculture, forestry, or fisheries, as well as parts of the larger economic, societal, and natural environments in which they are embedded" (H. Nguyen, 2018). Food systems may be examined at different scales (from global to local) and even at the household level (HLPE, 2017). Within any given country, many food systems coexist simultaneously. With those caveats in mind, typologies are valuable because they demonstrate the complexity of food systems and enable researchers and policymakers to consider the diversity of the systems when formulating policies and interventions tailored to a specific setting (Ericksen et al., 2012).

2.1.1 Global and Local Food Systems

On the one hand, Global food systems, characterized by trade liberalization and international food trade have facilitated major advances in agricultural productivity in the last 50 years, with crop output tripling (FAO, 2017). These advances have mostly been in grain production (rice, maize, and wheat), which has increased by about a billion metric tons since the mid-1960s (FAO, 2003). In the 1950s when the threat of famine dreaded policy makers, malnutrition was seen only from the point of undernourishment in developing countries. At that time, the focus was to increase production of commodities that were rich in calories and make it affordable to the poor at a low cost (Pinstrup-Andersen and Hazell, 1985). The 'Green Revolution' as was fondly called resulted in increase in output which was essential to reducing hunger, and the proportion of individuals in resource-poor nations with average daily food intakes of less than 2200 kcal declined from 57 percent in the early 1960s to just 10 percent by the end of the century (Pingali et al., 2006). During that period, the price of cereals such as rice, maize and wheat fell relative to prices of high value commodities (pulses, fruits and vegetables). A possible explanation could be greater productivity gains from input subsidies, credits, and the reallocation of land for cereals production. The result was that high value foods became expensive and less affordable to the poor (Bouis, 2000). In addition, the high dependence on exports of these commodities for foreign exchange generation left developing countries vulnerable to changing external conditions (Rutten et al., 2013). Also, when confronted with imminent food shortages or sharp price increase, governments in developing economies believe that the heavy agricultural subsidy policies in industrialized countries distorts trade, particularly their exports, hence they implement protective trade policies. However, some of the protective policies have backfired, especially in LMICs, leading to increases in domestic price and domestic price volatility (Porteous, 2017; Smith & Glauber, 2020).

Local food systems (LFS), on the other hand, characterized by high levels of food self-sufficiency, have been put forward as developing countries, particularly the poor countries, are uncompetitive enough to benefit from openness to trade and these countries typically resort to protectionist policies (De Schutter, 2017). The concept of food self-sufficiency refers to the extent to which a country can meet its food requirements through domestic production (FAO, 1999). In practice, food self-sufficiency indicates that a country produces a proportion of its food needs that approaches or exceeds 100 percent of its food consumption (Clapp, 2015). The effectiveness of food self-sufficiency as a national policy objective has however been the subject of lengthy debate. A policy measure of food self-sufficiency can provide governments with a contingency plan in the event of supply disruptions caused by war, a decline in food availability on international markets, or volatile food prices on international markets (FAO, 1996a). Countries may also pursue food self-sufficiency to strengthen their farm sectors and support overall economic growth and development, as well as to boost rural economic activity and incomes (Clapp, 2015). Food sovereignty advocates have also expressed strong support for increased food self-sufficiency based on agro-ecological farming methods as a means of increasing the resilience of local food systems (Wittman et al., 2010). However, some economists have long maintained that food self-sufficiency policies are deeply flawed due to the fact that policies designed to promote it are typically inefficient and trade-distorting (Naylor & Falcon, 2010). Imposing trade restrictions, tariffs, and subsidies in the name of food self-sufficiency is viewed as a risky and expensive policy.

Furthermore, many scholars argue that such policies undermine long-term food security because they limit opportunities to capture efficiency gains, which can lead to lower food production and higher food prices (Clapp, 2015).

2.1.2 The Nutrition Transition

The challenge with today's food systems is that they are no longer in sync with shifting global priorities, and they have several interlinked vulnerabilities that are driving today's nutrition crisis and restricting their capacity to provide sustainable, nutritious meals for everyone. It is no longer enough for food systems to just provide food for the population. They must feed individuals in ways that promote human health while also assuring sustainability (Global Panel on Agriculture and Food Systems for Nutrition., 2020). Over the last 30 years, countries have grown economically, and have undergone a "nutrition transition," in which higher incomes translate into a desire for more calories, followed by a demand for more protein (mainly from animal sources) and other nutrients from nuts, fruits, and vegetables. A similar trend is the increased intake of sugar, oils, and fats via processed meals (B. M. Popkin, 2017; B. M. Popkin & Gordon-Larsen, 2004). Rising national incomes often result in a decrease in the proportion of disposable income spent on food (Engel's rule) and a trend toward greater calorie intake and more diversified diets (Bennett's law) (OECD, 2021; Reardon et al., 2003). The nutrition transition can be observed in both developing and developed countries.

Poor people in developing countries often get a big portion of their energy from basic foods. Higher-value and more nutritious foods such as fruits, vegetables, and animal products are becoming more important as living standards grow. This sort of dietary change is nutritionally beneficial. However, another form of nutritional shift often happens concurrently. Economic growth, urbanization, and globalization all contribute to altering lifestyles, which include shifting consumer tastes, purchasing patterns, eating surroundings, and a trend toward Western-style diets (Mergenthaler et al., 2009; Pingali, 2007). Traditional dietary components are rapidly being replaced by processed meals and convenience items that are low in fiber but rich in fat, sugar, and salt (Gomez & Ricketts, 2013; Hawkes, 2008; B. Popkin, 2014). This shift is less desirable in terms of nutrition. High fat and sugar consumption, along with decreased levels of physical activity at work and in leisure time, results in increased rates of overweight and obesity, as well as an increase in noncommunicable diseases (B. Popkin, 2014; B. M. Popkin, 2006). In many developing countries, people are undernourished (having inadequate calories), micronutrient deficient (due to a lack of the proper balance of nutrients), and over-nourished (having unhealthy foods). There is also a dearth of clean water, public health, and specific nutrition aid, particularly for mothers and children, in these countries (Global Nutrition Report, 2018; Pingali & Sunder, 2017).

Developed countries, on the other hand, have more stable food preferences, with slower income growth and less sensitive consumption patterns to income fluctuations. These patterns often include a heavy consumption of meat, dairy, vegetable oils, and sweets (due in part to the consumption of more processed food products). However, overconsumption is growing, resulting in a greater percentage of the population being overweight or obese (OECD, 2021). Ultra-processed foods that are poor in nutritional value but rich in energy currently account for 30 to 60 percent of the total dietary energy eaten in countries with high incomes (South et al., 2019). Higher urbanization and increased female labor-force involvement are two variables driving increased consumption of processed foods and a growing desire to eat outside the house (Cutler et al., 2008; Seto & Ramankutty, 2016), while increased sedentariness is another factor driving rising obesity trends (Graf & Cecchini, 2017). According to a study in the United States, other contributing factors that have been identified include a lack of inexpensive and nutritious food alternatives ("food deserts") or a large concentration of fast food outlets ("food swamps") (Ver Ploeg & Rahkovsky, 2016).

Providing healthy and sustainable meals is a global priority, and food systems all around the globe are at the heart of achieving this goal. The primary requirement, however, is to achieve universal food security and nutrition.

2.2 Food and Nutrition Security

With the introduction of the SDGs in 2015, food security has been acknowledged as a global objective. The seventeen SDGs, as outlined in the 2030 Agenda for Sustainable Development, constitute a "plan of action for people, planet, and prosperity" agreed by 193 United Nations (UN) Member States, with 169 related objectives to be met by 2030 (United Nations General Assembly, 2015). Specifically, the second Goal of "Zero hunger" is to eradicate hunger and all forms of malnutrition by 2030. However, with less than 8 years till 2030, the world is not on track to reach this goal, since every region of the world is still impacted by one or two forms of malnutrition, and one of the greatest health concerns confronting most development policymakers is how to combat all forms of malnutrition (Micha et al., 2020).

Food security is a multifaceted subject. As defined by the FAO, food security is a state in which "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996b). This notion of food security yields four pillars or dimensions: availability, accessibility, utilization, and stability.

2.2.1 Pillars of Food Security

1. Food Availability: This refers to the supply side of food security and the physical availability of food sufficient quantity and quality, whether generated from domestic agri-food production, domestic stocks, food imports, food aid, or a combination thereof. Households and individuals must have enough access to food once it is available (FAO et al., 2019).
2. Food Accessibility: Food access refers to the demand side of food security and is accomplished through adequate income or other means to secure appropriate food for a healthy diet (FAO, 2008). Sufficient food supply does not ensure food security for families or individuals, because food access is sometimes more difficult than availability, particularly for the most malnourished people (World Bank, 2007). A person's economic and social access is influenced by disposable income, food prices, and the availability and accessibility of public assistance programs. Infrastructure and other market-supporting facilities have a significant impact on the ease of physical access. Food security demands that households eat appropriate nutrients and energy if food is accessible and households have adequate access (FAO et al., 2019).
3. Food Utilization: This relates to how the body uses the nutrients in meals to their fullest potential. Good care and feeding habits, food preparation, diet variety, and intra-household food distribution all contribute to adequate energy and nutritional intake for individuals. Energy and nutrient intake, together with the body's ability to use the food that is taken, work together to define an individual's nutritional status (FAO et al., 2019). Nutrition is an essential component of food security and hence has a vital place. Food security cannot be achieved without proper nutrition.

4. Food Stability: The other three dimensions are said to be stable if and only if this dimension of food security is present. Even if a person's current food consumption is adequate, food insecurity still exists if a person experiences periods of time without enough access to food. Stability refers to both short-term instability, which may lead to acute food insecurity, and medium- to long-term instability, which can lead to chronic food insecurity (FAO et al., 2019).

To ensure a healthy diet, the four dimensions of food security play an important role.

2.2.2 Food Insecurity and the Triple Burden of Malnutrition

Food insecurity leads to malnutrition and health problems. Malnutrition is an abnormal physiological state induced by insufficient, imbalanced, or excessive ingestion of macronutrients and/or micronutrients, according to (FAO et al., 2019). In the 1960s and 1970s, after the Green Revolution, there was a greater understanding that malnutrition encompasses two other dimensions, namely micronutrient deficiencies and overweight and obesity, in addition to insufficient intake of dietary energy and protein (so-called "undernourishment"). Consequently, the issue is now often referred to as the "triple burden" of malnutrition (Labadarios, 2005; Pinstrup-Andersen, 2007). Malnutrition may be caused by food poverty or by nonfood factors such as poor childcare, insufficient health services, and an unpleasant environment (FAO et al., 2019). The 2020 COVID-19 epidemic resulted in worldwide recession and generated significant setbacks. According to the FAO, the pandemic may have resulted in an increase of 150 million undernourished people (FAO et al., 2022). In LMICs, disruptions caused by COVID-19 might result in an extra 9.3 million wasted children, 2.6 million stunted children, 2.1 million anemic women, 2.1 million infants born to mothers with a low body mass index, and 168,000 more child fatalities by 2022, according to simulations (Osendarp et al., 2021). Furthermore, the percentage of people in LMICs who cannot afford a nutritious diet jumped from 43% to 50% in the first year of the epidemic (Laborde et al., 2021). The epidemic has had a wide-ranging impact on the food supply chain and agricultural trade regulations, including temporary export prohibitions (FAO et al., 2020; Kerr, 2020; WTO, 2020). Many people have lost their employment because of the economic downturn, and they now rely on government help to support their families. Global consumption of comfort foods such as fried meals and sugary sweets is also on the rise and this might lead to an increase in malnutrition and diet-related disorders (Lin et al., 2021; Robinson et al., 2021).

However, even before the pandemic, food systems were failing to handle the triple burden (OECD, 2021). While progress has been recorded towards the reduction of the prevalence of undernourishment (PoU), with most nations currently exhibiting lower percentages than they did in the early 2000s, in absolute terms however, the number of undernourished people is on the rise again, with an estimated 702 and 828 million people (or 11 percent of the world's population) presently suffering from hunger in 2021. More than half (425 million) of the total number of undernourished people reside in Asia (20.2%), and more than one-third (278 million) live in Africa (9.1%), with Latin America and the Caribbean accounting for roughly 8.6% (56.5 million). While Asia has the majority of the world's undernourished population, Africa has the highest prevalence (FAO et al., 2022). This burden of malnutrition remains intolerably high, and improvement is sluggish. For children under the age of five, 149.2 million are stunted (22%), 45.4 million are wasted (6.7%), and 39 million (5.7%) are overweight. 571 million girls and women of reproductive age (15–49 years) are anaemic, and around 3.1 billion people are unable to afford healthy diets. Also, 675.7 million adults are obese (FAO et al., 2022). Malnutrition in any form is linked to a variety of health problems and a greater risk of death. More than a quarter of global preventable deaths are attributable to unbalanced diets, primarily due to diet-related chronic diseases that require expensive treatment (Stanaway et al., 2018). Undernutrition accounts for around 45 percent of mortality among children under the age of five, mostly in low and middle-income countries. According to a study by Global Burden of Disease, dietary risk factors were responsible for 11 million deaths worldwide in 2017, with the three biggest risk factors being excessive salt consumption, low whole grain intake, and low fruit intake (Afshin et al., 2019). According to the same study, healthier diets might avert one in every five deaths worldwide. Malnutrition is not just a health concern; it also has a social, economic, developmental, and medical impact on people, their families, and communities, with significant and long-term implications. If trends continue, economic losses from heart disease, cancer, diabetes, and chronic respiratory illness in low- and middle-income nations would exceed USD 7 trillion between 2011 and 2025, comparable to around 4% of these countries' annual GDP (UNICEF, 2019).

It is believed that shifts in food systems, unhealthy eating habits, economic development, income growth, trade liberalization, and globalization tendencies contribute to the global prevalence of malnutrition, and its subsequent relocation to LMICs (OECD, 2021).

2.3 Impact of Trade on Food and Nutrition Security

While sustainable, inclusive, and healthy food systems are being championed as a significant impact route for improving nutrition (C. Carletto et al., 2013), how to reach this objective is the subject of heated policy and scientific debate, with an emphasis on the role of trade and the scale at which food systems should function (Martin, 2018).

According to the FAO & WHO (2017), "Trade is intrinsically related to food security, nutrition, and food safety." Trade influences a vast array of economic and social factors, such as market systems, the productivity and composition of agricultural production, the diversity, quality, and safety of food items, and the composition of diets. As a consequence of globalization, many countries' food systems have undergone rapid transformations. Over the past several decades, increased levels of international trade in food and agricultural products have played a critical role in ensuring a sufficient supply of staple foods while also maintaining dietary diversity in the provision of nutritious foods, particularly in areas where fresh fruits and vegetables are scarce for a part of the year. However, trade policies, particularly protectionary trade measures, may have an impact on the availability and cost of nutritious meals in local markets, as well as the supply and price of energy-dense foods. Similarly, although non-tariff trade policies may assist enhance food safety, quality standards, and nutritional value, they can also raise trade costs and therefore food prices, reducing the affordability of healthy diets (FAO et al., 2022).

Food trade is expected to reduce undernourishment and micronutrient deficiencies in countries with better institutional quality and favorable agro-ecological conditions, but may increase obesity if relative prices for processed foods decrease. If domestic trade costs are high (which is the case for most African countries, regional or global trade may lead to better nutritional outcomes, particularly for undernourishment. Due to higher and more stable earnings from high-value exports, increase in this trade is expected to lead to less micronutrient deficiencies but more obesity (Porteous, 2017).

Trade is therefore critical in establishing the food security status of rural communities, especially low-income households. While trade policies are considered strategic to shape national food systems and promote food security, and there is a large body of literature on the effects of trade on poverty (Winters et al., 2004; Winters & Martuscelli, 2014), the nutritional implications of trade are much less studied, and the few available empirical studies provide mixed evidence.

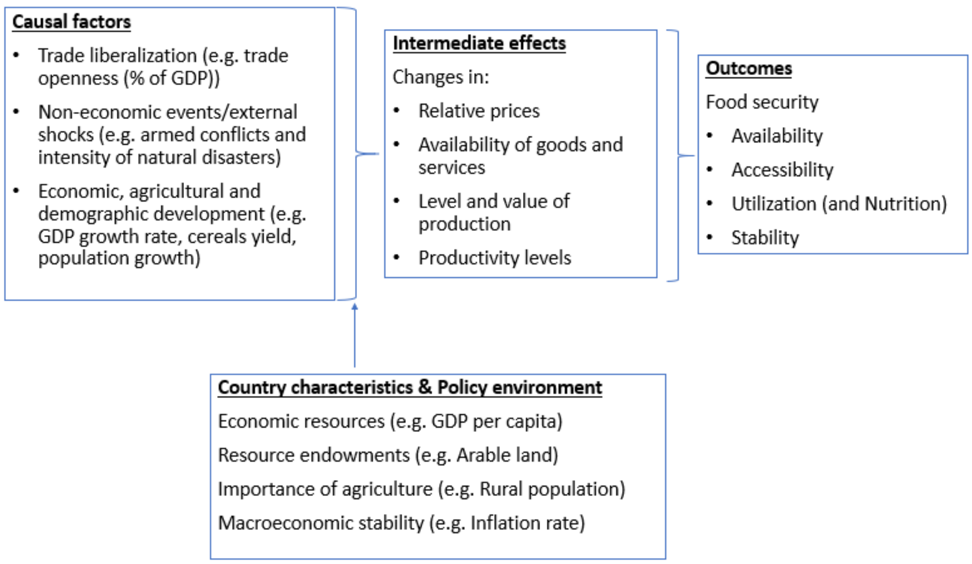
It is a daunting challenge to estimate how food trade influences nutrition. First, the link between trade and nutrition can vary over time and space, because of spatial trade specialization effects both across and within countries (Fajgelbaum & Redding, 2014; Fan, 2019). The volume and structure of international food trade has changed drastically during the past two decades, with a substantial increase in South-South trade and a shift in LMICs' exports from tropical commodities to high-value produce (Van den Broeck & Maertens, 2016). Distributional effects of trade liberalization affect consumers and producers differently, which implies non-uniform nutritional implications within countries (Cuevas García-Dorado et al., 2019). Second, the link between trade and malnutrition can also differ between different forms of malnutrition.

2.3.1 Conceptual framework

FAO, 2003 presents a conceptual framework for studying trade liberalization's impact on national-level food security (Figure 1). As can be seen in the figure, trade liberalization, together with other domestic macroeconomic reforms, external shocks/non-economic events such as natural catastrophes and violent conflicts, and economic and demographic growth (causal variables), have an influence on the pricing and quantities of manufactured and traded commodities (intermediate effects). Trade openness, for instance, are likely to result in modifications to border pricing and production incentives, and, consequently, modifications to domestic prices, the quantity and value of domestic production, and the availability of goods and services (including food). These effects will be impacted by (structural) country characteristics such as the level of economic development, the importance of agriculture, and the availability of economic resources, as well as the policy framework in which reforms are implemented. The country's characteristics and policy environment impact the market's ability to function and the adaptability of market participants to changes in price and incentives. Consequently, they determine the extent to which policy changes affect the prices and quantities of produced and traded commodities, and they may suggest that trade reforms have varying effects on the economy as a whole and on consumer welfare (FAO, 2003). By means of these processes, trade openness affects the several facets of food security (outcomes).

This framework is also compatible with UNICEF, 1990 conceptual model on the causes of child malnutrition, in which trade openness as a component of the political and economic structure could be conceptualized as a fundamental cause/determinant affecting incentives, food supplies, and financial resources, and thus household food security.

Figure 1: A conceptual framework for investigating the determinants that affect food security



Source: personal depiction based on (FAO, 2003).

In order to construct a broad framework that systematizes the existing literature and informs the interpretation of our empirical data, a review of the possible positive and negative implications of trade on the key aspects of food security (availability, access, and use) and their stability is explained below.

2.3.2 Impact of Trade on Food Availability

Ensuring availability entails ensuring that nutrient-dense, basic foods are obtainable to everyone and produced in an environmentally responsible manner. Numerous researchers report that, on average, greater levels of trade openness result in more food availability via both increased domestic food production efficiency and greater food imports for importing nations (Burgess & Donaldson, 2010; Dithmer & Abdulai, 2017; P. A. Dorosh & Rashid, 2013; Traverso & Schiavo, 2020; Wood et al., 2018). Indeed, trade openness tends to foster a more efficient use of resources via specialization, whilst increased competition and the availability of cheaper, higher-quality inputs might encourage local manufacturers to invest for productivity improvement (FAO, 2015).

In addition, nations lacking essential resources, like as land or water, may import food to meet unmet domestic demand and then concentrate in other industries where they have a competitive advantage (Anderson, 2016). Food import may also have a positive effect on the stability of domestic food availability in the event of negative production shocks, such as those caused by extremely disruptive natural events (P. A. Dorosh, 2001), or simply to compensate for seasonal shortages (FAO, 2015), which frequently play a significant role in malnutrition, especially among children (Chikhungu & Madise, 2014; Madan et al., 2018). (Baldos & Hertel, 2015) examine the role of international food trade in reducing the food security concerns associated with climate change, claiming that integrated markets would help to manage the short- and long-term implications by boosting food supply in vulnerable regions.

Empirical evidence also suggests that trade may offer several obstacles to food availability in low-income food-deficit nations. Growing trade in these nations raises the danger of heavy dependence on food imports. According to research in 129 LMICs, excessive export and import dependency on basic commodities had a statistically significant and negative influence on food security from 1995 to 2017 (FAO et al., 2019). Furthermore, from this research, 80 percent of the 129 countries that saw an increase in hunger during recent economic slowdowns had economies that are heavily reliant on main export or import goods (or both) . While countries' dependence on international food trade has been linked to agricultural intensification, which has resulted in significant increases in crop yield levels and lower food prices, it has also put local producers under increasing competitive pressure—and makes consumers more vulnerable to external shocks in food availability (De Schutter, 2011; Koning & Pinstrup-Andersen, 2007; Mary, 2019). Higher prices in international markets can incentivize domestic producers to divert production from national markets to export (FAO, 2015). When faced with immediate food shortages or significant price increases, governments in developing economies feel that industrialized nations' large agricultural subsidy programs hinder trade, therefore they enact protective trade regulations. However, some of the protective measures have backfired, causing domestic price rises and volatility (Porteous, 2017; Smith & Glauber, 2020). A study also finds that developing nations often limit food trade openness in reaction to hunger crises, with a 0.9 percent increase in hunger prevalence resulting in a 0.9 percent drop in food trade openness. This may be viewed as proof of 'food protectionism.' (Mary, 2019).

2.3.3 Impact of Trade on Food Accessibility

According to some scholars, trade openness promotes economic prosperity and market stability for both food and non-food producers and consumers, as a result of higher average real incomes due to cheaper inputs, greater market access for exports, new employment opportunities, and lower and more stable domestic food and non-food prices (Anderson, 2016; Asche et al., 2015; Dávalos et al., 2020; P. Dorosh et al., 2009; P. A. Dorosh & Rashid, 2013; Houssa & Verpoorten, 2015; McCorriston et al., 2013; Montalbano et al., 2018; Porteous, 2017; Rutten et al., 2013; Traverso & Schiavo, 2020). (Dorosh et al., 2009) for instance, examine the production and trade of maize and cassava in Zambia in 2006 and propose regional trade as a means of reducing local price volatility. (Porteous, 2017) examines the effect of maize export prohibitions on prices in five countries in East and Southern Africa, where temporary restrictions were extensively enacted to stabilize local prices of staple grains during the 2007–2008 food price increase. Results indicate that export restrictions raise prices and price volatility in nations that apply them. Conversely, (Bouët & Laborde Debucquet, 2012) find a decline in national welfare for small net food importers in the simulation of export taxing and absence of coordination of trade policy. (Dávalos et al., 2020) examine the effect of trade openness through the price variation of chemical fertilizers in rural Vietnam, demonstrating that liberalization increased rural household participation in farm employment, with direct effects on food availability due to increased productivity and indirect effects on food accessibility due to increased farmers' income. (P. A. Dorosh & Rashid, 2013) discuss the Bangladesh-India rice trade in the 2000s and the substantial reduction in exchanges after the global financial crisis of 2007. Through model simulation, the authors demonstrate that trade liberalization would have reduced the need for public rice stockpiling, demonstrating a favorable impact of trade on both supply and access. According to (Dithmer & Abdulai, 2017), trade openness boosts food supply and dietary variety in both developed and developing nations.

On the other hand, many academics suggest that greater trade openness exposes nations to economic shocks, resulting in higher and more unpredictable food prices in food-importing countries and increasing the vulnerability of poor families (Béné et al., 2010; Cathie & Herrmann, 1988; Flachsbarth & Garrido, 2014; Headey, 2011; Madeley, 2000; McCorriston et al., 2013; Rosset, 2008; Rutten et al., 2013) (Headey, 2011), for instance, demonstrates how trade disruptions led to the 2008 increase in food prices. Similarly, (Flachsbarth & Garrido, 2014) explore how varying degrees of trade openness affected the transmission of world food prices to local markets in six Latin American nations. They assert that more market integration enhances global price transmission elasticity, and that greater agricultural trade openness is related with higher food CPIs during global price spikes. In addition, trade openness may raise the price of exported goods and reduce people's buying power, while income and employment in import-competing industries might be adversely impacted by the increased competition (FAO, 2015). (Delgado et al., 2005) highlight the non-tradability of a large proportion of staple crops in a number of African nations, urging caution in evaluating the positive income impact of trade intensification. (Wobst, 2003) finds that comparable trade policy initiatives may have varying effects on family income and marketing margins depending on the underlying economic structures of the various nations. (Mary, 2019) investigated the effect of food trade openness on PoU in a sample of 52 developing nations between 1990 and 2013 and found evidence that food trade openness affects undernutrition in developing countries. Specifically, it was revealed that a 10 percent rise in food trade openness would raise the PoU by around 6 percent and that a 10% rise in agricultural trade openness leads to a 2.1% increase in child stunting in the short term.

2.4.4 Impact of Trade on Food Utilization

Some researchers found a positive relationship between food utilization and trade, citing access to a broader variety of food and a better level of compliance with international standards regarding nutritional requirements (FAO, 2015). Khoury et al. (2014) note that agricultural intensification and specialization have resulted in an increased homogeneity in global food supplies with a higher share of energy-dense but nutritious-poor crops, thereby lifting millions of people out of hunger but not necessarily ensuring access to required micro-nutrients. Using a mixed sample of developed and developing countries, Levine & Rothman (2006) discover that trade openness reduces child stunting. According to Marson et al. (2022), trade openness also helps to reduce the PoU in developing countries, and the majority of this effect is not income-mediated, but rather occurs through the impacts that it has on the other dimensions of food security.

Traverso & Schiavo (2020) examine the development of trade in macronutrients (carbohydrates, lipids, and proteins) in 71 low-income countries from 1996 to 2014. Their findings indicate that participation in international food trade has favorable impacts on the availability and accessibility of macronutrients in low-income countries, which may lead to increased food utilization. According to these authors, low-income nations have a net import of all the examined macronutrients and profit from the advantageous price disparity between exports and imported nutrients. Similarly, Wood et al. (2018) demonstrates that, on average, trade adds to the distribution of nutrients across nations and enhances countries' capacity to achieve their nutritional demands, especially for macronutrients, by comparing trade to no-trade scenarios in the period 2007–2011. (i.e., protein and carbohydrates).

Some researchers however identify a positive and significant relationship between trade openness and/or globalization and obesity, with a higher effect for developing countries. An et al. (2019) and Blouin et al. (2009) identify a positive link between trade openness and a rise in obesity and poor diets, with increased intake of calorie-rich and nutrient-poor foods after trade liberalization in some developing nations. However, they find that in several low-income nations, trade would reduce the availability of some micronutrients. A meta-analysis on nutrient-income elasticities in Africa concludes that while income growth will increase food consumption and diversity, it is also associated with excessive intakes of fats and sugars, suggesting that trade may lead to increased rates of obesity (Colen et. al et al., 2018). However, other researchers contend that the impact of trade openness on overnutrition in poor countries is exaggerated, and that the growth in obesity may be better explained by broad modernization trends than trade itself (Fox et al., 2019; Mary & Stoler, 2021).

2.4.5 Impact of Trade on Food Stability

Trade may assist in balancing out excess demand or surplus supply on domestic markets, stabilizing national food supplies and reducing price fluctuations. A more open trade system may reduce the supply unpredictability of (essential) goods compared to a self-sufficiency plan, since countries have more options to increase food availability. Additionally, it alleviates some of the expenditures associated with costly stock ownership activities (FAO, 2005). Deeper global food markets, more foreign currency availability as a result of increased export earnings, and an open trade policy may thus help to stabilize local food supplies and enable global production to occur in the most suitable regions. Domestic shocks are often more frequent and severe than foreign shocks. As a result, international trade plays a significant role in lowering volatility by allowing nations to use global markets in response to internal shocks (OECD, 2013). The buffering role of trade also necessitates that nations refrain from implementing policies that impede the effective operation of international markets (OECD, 2021). In 2007-08, in response to rapidly escalating food prices, a number of major grain exporting nations-imposed export curbs or prohibitions in an effort to preserve domestic supply for local consumption (Jones & Kwieciński, 2010). These kinds of acts lead to market volatility in international markets, which has a detrimental impact on global food security. Trade openness may not be enough to withstand uncommon but significant worldwide shocks, such as simultaneous crop failures or interruptions in global supply chains, as witnessed during the COVID-19 crisis. Nonetheless, governments often utilize trade policy tools to impact the stability of domestic markets. Price controls and border barriers have long been used by Asian rice producing and consuming nations to stabilize local prices (Timmer & Peter, 2010). African interventions have often destabilized local markets (Jayne & Tschirley, 2009). Domestic trade policy initiatives seem to have had little influence on lowering domestic pricing instability globally (Anderson & Nelgen, 2012). The adoption of trade policies to protect countries against global price shocks can only shift the risks associated with commodity production and trading. If several nations attempt to shift pricing risk to others, the result is likely to be ineffectual (Martin & Anderson, 2012).

3.0 Data and Methods

An explanation of data collection and the econometric methodologies for data analysis is described in this section. For the dependent and independent variables, a panel dataset of 114 countries from 2001 to 2018 was employed (as shown in figure 2 below). This was an era that saw fast globalization and international trade problems occurring at the same time. Appendix 1 shows the list of countries selected and utilized for the study. The dataset was obtained from Food and Agriculture Organization Statistical Database (FAOSTAT) and World Development Indicators (WDI). Data availability dictated how the dataset was constructed. The countries were grouped in the following regions: East Asia and Pacific (EAP), Europe and Central Asia (ECA), Latin America and Caribbean (LAC), Middle East and North Africa (MENA), North America (NA), South Asia (SA), and Sub-Saharan Africa (SSA). More importantly, the countries were divided into four income groups: High income (HI), Upper middle income (UMI), Lower middle income (LMI), and Low-income countries (LI).

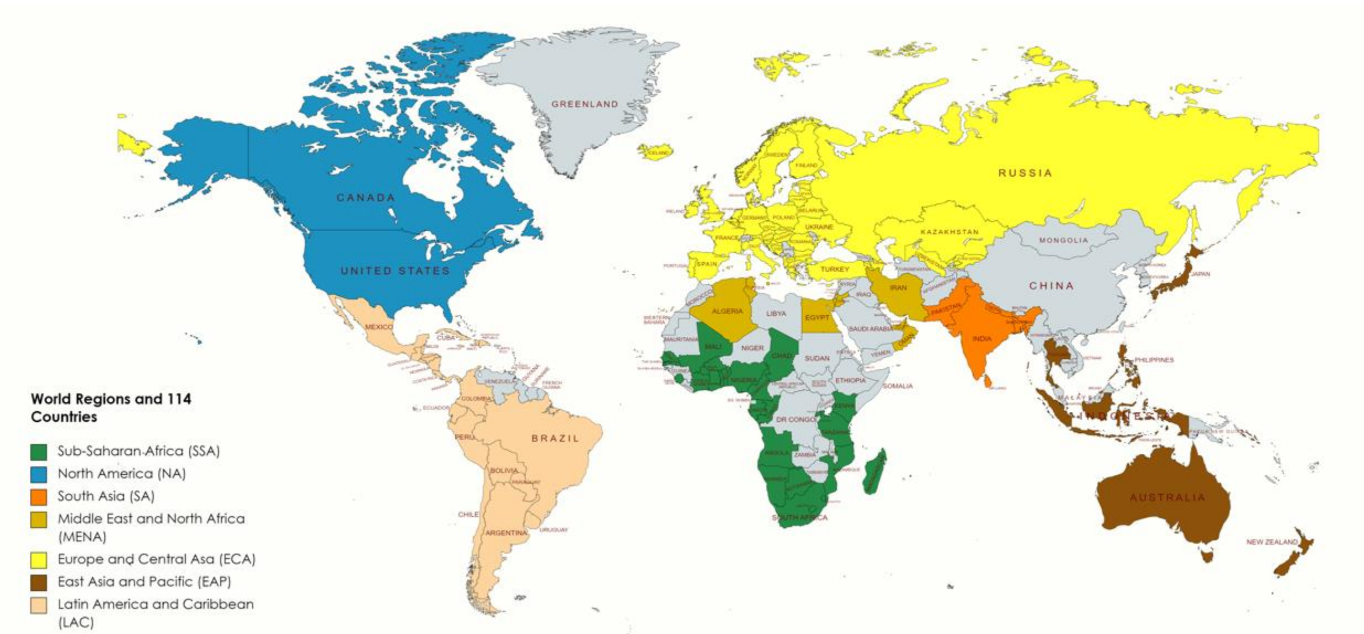


Figure 2: Countries selected for the study based on data availability

3.1 Data sources and description

It is important to recognize that food security is a complex concept. As a result, there is no one, widely acknowledged indicator of food security (C. Carletto et al., 2013). This is because food security cannot be quantified directly, hence, proxy indicators are utilized (Barrett, 2010). To monitor the worldwide battle against hunger, I evaluate food and nutrition security by concentrating primarily on the prevalence of undernourishment, anaemia, and obesity, as reported by FAO and embraced by both SDG initiatives (Goal 2, SDG Indicator 2.1.1, 2.2.2 and 2.2.3 respectively). The choice of variables was influenced by the conceptual framework (detailed in Chapter 2 – Literature review), previous research, and data availability.

1. **Prevalence of undernourishment**

Hunger—the unpleasant or painful feeling induced by inadequate ingestion of dietary energy—is a crucial indication of food insecurity, and it is measured as the PoU. It is one of the indicators for the "Access" dimension of food security. According to the UN Statistics Wiki, 2019, undernourishment is described as "chronic hunger, a situation in which a person has insufficient access to food quantities enough to supply the energy needed for living a normal, healthy, and active life, given their particular dietary energy needs for at least one year." Food available for human use is the total of domestically produced and imported food items less food exports, food withdrawn from stocks for non-human consumption reasons (feed, seed, industrial usage), and food losses. This is then transformed into dietary energy terms expressed in kilo-calories and divided by the total population and the number of days in the year to get the average daily dietary energy available for human consumption. This dietary energy value serves as a proxy for habitual daily dietary energy intake per capita.

The minimum level of dietary energy needs, or cut-off point, is calculated within a probability distribution of habitual dietary energy intake using energy standards defined by the FAO/WHO/UNU for different gender and age groups. For attained heights, the minimum level of requirements corresponds to sedentary physical activity and a minimum acceptable body weight. Since adults' energy requirements are almost twice those of a three-year-old child, calculating the minimum energy demand per capita in a country must take into consideration the population's sex-age composition. As a result, the daily per capita energy requirements used as a cut-off point for estimating undernourishment in a given year are calculated at the national level, based on the dietary energy needs of various age and sex groups, as well as the proportion of the population represented by each sex-age group. The indicator goes from 0% (no undernourished people) to 100% (the entire population is undernourished).

Table 1: Undernourishment categories

Percentage	Prevalence
<5%	Very low
5% - >14.9%	Moderately low
15% - >24.9%	Moderately high
25% - >34.9%	High
35% and over	Very high

Source: FAO metadata, 2022

2. Prevalence of anaemia among pregnant women

Micronutrient malnutrition refers to deficits in vitamins and minerals essential to optimal health and is the result of a poor diet and illness. The prevalence of micronutrient deficiency, sometimes known as "hidden hunger," is reported at the national or population level, but reporting may be tailored to susceptible demographic groups (Bahn et al., 2021). The micronutrient deficiencies that pose the greatest threat to public health are vitamin A, iron, and iodine, especially among children less than 5 years old, pregnant women, and women of reproductive age. Vitamin A deficiency causes blindness in children and increases the risk of infection-related illness and mortality. Women are more susceptible to iron-deficiency anaemia, which has a negative impact on their mental ability and productivity at work (HLPE, 2017). Anaemia is a condition in which the amount of red blood cells (and hence their ability to transport oxygen) is inadequate to fulfill the body's physiologic demands. The prevalence of anaemia among pregnant women (PoA) represents the proportion of pregnant women whose hemoglobin level is less than 110 g/L at sea level. It is an important health indicator, and when combined with other iron status tests, haemoglobin concentration may offer information on the severity of iron insufficiency (WHO, 2011). It is one of the indicators for the “Utilization” dimension of food security.

Table 2: Haemoglobin levels to detect anaemia at sea level (grams per litre)

		Anaemia*		
Population	Non-Anaemia*	Mild	Moderate	Severe
Children 6 - 59 months of age	110 or higher	100-109	70-99	lower than 70
Children 5 - 11 years of age	115 or higher	110-114	80-109	lower than 80
Children 12 - 14 years of age	120 or higher	110-119	80-109	lower than 80
Non-pregnant women (15 years of age and above)	120 or higher	110-119	80-109	lower than 80
Pregnant women	110 or higher	100-109	70-99	lower than 70
Men (15 years of age and above)	130 or higher	110-129	80-109	lower than 80

Source: (FAO & WHO, 1992; WHO et al., 2001)

3. Prevalence of obesity among adults (aged 18+)

Overweight and obesity are caused by an excessive consumption of dietary energy and are often quantified by the Body Mass Index (BMI) (Bahn et al., 2021). Globally, across all locations, and across all age categories, the prevalence of overweight and obesity continues to increase. Between 2000 and 2016, the prevalence of overweight among adults increased dramatically in every area by around 10 percentage points (FAO et al., 2019). The prevalence of obesity among adults (PoO) is defined as a Body BMI of 30 kg/m2 or greater in those aged 20 and up. BMI is computed by taking the subject's weight in kilograms and dividing it by their height in meters squared. It is also one of the indicators for the "Utilization" dimension of food security.

Table 3: Classification of Overweight and Obesity by Body Mass Index (BMI), Waist Circumference, and Disease Risk

BMI (kg/m2)		Obesity Class	Disease Risk* (Relative to Normal Weight and Waist Circumference)	
			Men ≤40 inches (≤ 102 cm) Women ≤ 35 inches (≤ 88 cm)	> 40 in (> 102 cm)
				> 35 in (> 88 cm)
Underweight	< 18.5		-	-
Normal	18.5–24.9		-	-
Overweight	25.0–29.9		Increased	High
Obesity	30.0–34.9	I	High	Very High
	35.0–39.9	II	Very High	Very High
Extreme Obesity	≥ 40	III	Extremely High	Extremely High

Source: (James et al., 2001)

Following the research of (Dithmer & Abdulai, 2017; Marson et al., 2022; Mary, 2018, 2019), five sets of food and nutrition security drivers were selected for this study. The variables associated to these drivers are explained below and summarized in Table 1.

Agri-food trade openness variable

This is the explanatory variable of most interest in the study**.** Trade openness is defined as the sum of the value of exports and imports divided by GDP. This trade openness measure is commonly used in impact studies of trade openness, and it is arguably better than de jure measures (e.g., tariffs) because the latter are difficult to summarize in a single indicator (Dithmer & Abdulai, 2017). It has significant advantages in that it can reflect the entirety of a country's commercial transactions (M. L. T. Nguyen & Bui, 2021). Constructing agri-food trade openness first requires agricultural exports and imports, as well as GDP. Firstly, data was obtained from FAO database on total exports and imports values of agricultural products, cereals, fresh fruits and vegetables, tropical commodities, in US dollars. Secondly, GDP was obtained from the WDI database. Lastly, agri-food trade openness was obtained by dividing agricultural imports and exports by GDP.

Variables that consider the characteristics of the country

These variables capture country's degree of economic growth, the availability of agricultural resources, and the importance of agriculture in the country.

Real GDP per capita is used to reflect average income and how changes in the economic environment might impact people's buying power and, hence, food security through economic access to food (Marson et al., 2022).

Rural population is the percentage of the total population that lives in rural areas. Since the poorest nations tend to have a higher proportion of rural populations and because food insecurity is more common in rural areas (FAO, 2003), a higher proportion of rural residents may be reflected in lower national food security. It also reflects one crucial aspect of domestic resource endowments, namely rural population resources, especially the agricultural labor force, which may positively impact food production and food availability.

The arable land variable measures the amount of land that may be used for agricultural production. This includes land that is temporarily planted with crops, meadows that are used for mowing or grazing, market or kitchen gardens, and land that is temporarily fallow. Food security is predicted to improve as a result of an increase in the amount of arable land accessible to each person in the country (Dithmer & Abdulai, 2017).

Variables that capture the agricultural, economic, and demographic development

GDP growth rate is a common indicator of economic progress. Economic growth is commonly seen as the most significant factor impacting income-based and food poverty and is projected to lead to a larger supply of goods and services (including food) (Ames et al., 2001; Haddad, et al., 2003). It is used to represent cyclical swings in production or economic growth. Sharp production contractions (or cyclical downturns) have been observed to exacerbate poverty (Agénor, 2004) and may thus undermine food security.

The demographic change is captured by the population growth variable. As the population grows, so does the demand for food, which might lead to a decrease in the amount of food available to each person. Also, population pressure has a wide range of impacts on the economy, including education levels and job prospects, and on the environment, which might have a negative impact on food security Hence, this variable is used to measure the impact of population expansion on food security (Dithmer & Abdulai, 2017; Marson et al., 2022).

Yield of cereals (kg per hectare) is used as a proxy for agricultural productivity. Closing the yield gap is usually considered to be one of the best ways to alleviate food insecurity (Godfray et al., 2010). The domestic food supply should be positively impacted by increased agricultural output.

Variables that capture non-economic events/external shocks

Natural and human-induced disasters are two sorts of non-economic occurrences that I take into consideration. To assess the first, the intensity of natural disaster is measured as the number of people divided by the total population, according to data from the Emergency Events Database (EM-DAT). Natural disasters are one kind of external shock or non-economic occurrence that may result in significant crop losses, reducing food supply from domestic production and putting substantial strain on farm earnings. Another kind of external shock is armed conflict, which is a human-induced tragedy. More than 1.5 billion people are now living in conflict-ridden nations, according to the (World Bank, 2011). Conflict may be seen as a vulnerability element and is a key driver of structural food insecurity. It has broad development implications and may have a negative impact on food security through its effect on domestic food supply and access to food by causing lower preferences for market participation, income losses, and disruptions to transportation, trade, and markets, and thus domestic food chains (Gates et al., 2012; Reutlinger, 1986). Food insecurity, on the other hand, may cause or worsen conflict, therefore it may not be entirely exogenous (Messer et al., 2002). Data on armed conflict was obtained from the Peace Research Institute Oslo (PRIO)

Variables that assess domestic macroeconomic policies and circumstances other than trade policy

I use the consumer price index (CPI) inflation rate as a proxy for macroeconomic stability (also connected to monetary policy) as an extra measure to account more generally for the domestic macroeconomic policy environment, with high inflation being associated with weak macroeconomic policies. Domestic stabilization measures that create an economically stable environment have been shown to promote welfare, while macroeconomic instability has been shown to increase poverty, possibly adversely influencing family food security (Agénor, 2004). According to (Easterly & Fischer, 2001), the poor often name inflation as a top national issue, and there is a substantial relationship between decreased inflation and increased poor well-being. On the contrary, macroeconomic instability harms the poor, since high inflation rates destroy real incomes and the poor's assets (Ames et al., 2001). As a result, it is predicted to reduce purchasing power and food consumption.

Table 4: Variables description and sources

	Variables	Unit	Source	Time Period
Dependent variables (Indicators of nutrition security)	Prevalence of undernourishment (PoU)	Percentage %	WDI	2001 - 2018
	Prevalence of anaemia among pregnant women (PoA)	Percentage %	WDI	2001 - 2018
	Prevalence of obesity among adults (aged 18+) (PoO)	Percentage %	Global Health Observatory, WHO	2001 - 2016
Core explanatory variable	**Food trade openness**			
	- Agricultural trade openness (AFTO) - Cereals trade openness (CTO) - Fresh Fruits and Vegetables trade openness (FFVTO) - Tropical commodities trade openness (TCTO)	Percentage %	FAOSTAT & WDI	2001 - 2018
Control variables				
	Country characteristics			
	GDP per capita	US$	WDI	2001 - 2018
	Rural population	Percentage %	WDI	2001 - 2018
	Arable land	Hectares per person	WDI	2001 - 2018
	Agricultural, economic and demographic development			
	Agricultural productivity	Kg per hectare	FAOSTAT	2001 - 2018
	GDP growth (annual %)	Percentage %	WDI	2001 - 2018
	Population growth (annual %)	Annual Percentage %	WDI	2001 - 2018
	Non-economic events/external shocks			
	Intensity of natural disasters		EMDAT	2001 - 2018
	Armed conflict		PRIO	2001 - 2018
	Inflation, consumer prices (annual %)	Annual Percentage %	WDI	2001 - 2018

Note: FAOSTAT—Food and Agriculture Organization Corporate Statistical Database; WDI—World Development Indicators; GDP—Gross Domestic Product; EM-DAT—Emergency Events Database, PRIO—The Peace Research Institute Oslo.

3.2 Empirical specification and estimation

I approach trade openness as endogenous due to the possibility of reverse causation, since nations may implement protectionist policies in reaction to previous food security shocks. Endogeneity is defined as the presence of a correlation between the dependent variable and the error term that is connected to the causal connection between the variables explained by the model. Endogeneity in economic terms may be described as the influence of the past on the present, both on the model (dependent variable) and on the independent variables, or as the causation link between regressors and explanatory variables across time.

Previous studies have used different models to correct for the endogenous nature of trade openness. Dithmer & Abdulai (2017) used a System Generalized Method of Moments (GMM) estimator that employs appropriately lagged observations of possibly endogenous variables as instruments to confirm that the direction of causality goes from the explanatory factors to the dependent variable (and not vice versa). System GMM estimators can be used for dynamic models, however they are susceptible to identification and weak instrument concerns (Bazzi & Clemens, 2013). Mary, (2019) employed an empirical technique based on the instrumental variable (IV) approach, but in the absence of a suitable instrument for trade openness, models the influence of food security (instrumented by rainfall anomalies) on trade openness, and then uses the residual trade openness that is not explained by food security as an instrument in his main model. Marson et al. (2022) took inspiration from Romalis (2007) who proposed an alternative instrument for trade openness by taking the United States (US) Most Favored Nation tariff rates and recognizing that how internationally integrated a country is depends both on its own policies and on the policies of its trading partners. In other words, countries would become more vulnerable to trade when also the trading partners liberalize their trade regimes. On the basis of this intuition, they hypothesized that the openness of trade partners and, more broadly, the average trade openness of the world impact each country's exposure to trade. However, this instrument is more statistical in nature and is not particularly relevant in economic research.

3.2.1 Two-stage Least Square (2SLS) Instrumental Variable Estimation Strategy

To examine the effects of trade openness on food and nutrition security, I specify the below static model with fixed effects (FE):

$$FNS_{i,t} = \alpha + \gamma_1 TO_{i,t} + \gamma_2 \boldsymbol{X}_{it} + \vartheta_i + \mu_t + \varepsilon_{it} \qquad (1)$$

where

- The $FNS_{i,t}$ represents food and nutrition security and is represented by the PoU, PoA, and PoO in country *i* and time *t*.
- α is the constant term, and γ_1 and γ_2 are the parameter coefficients to be estimated.

- TO is the trade openness measure. This would be further disintegrated into trade openness measures for total agricultural products, Cereals, Fresh fruits and vegetables, and Tropical commodities. The primary focus is on the parameter estimates for γ_1, which represent the influence of trade openness on our outcome variables $FNS_{i,t}$. A positive estimate for trade openness indicates that, after adjusting for all control variables, trade openness increases PoU, PoA, and PoO (and vice-versa).
- X is a collection of control variables thought to be major potential drivers of national food and nutrition security. These are variables captured in sub-section 3.1.2 to 3.1.5.
- ϑ_i denotes country-specific effects, for instance, geographical qualities or relatively consistent cultural and institutional traits that cannot be observed, and do not change over time and that may influence production outcomes.
- μ_t is the time-specific effect, capturing changes in global prices and adjusting for shocks that affect all countries,
- ε_{it} is the idiosyncratic error term.

Achieving unbiased estimates of the trade openness effect requires overcoming two estimating challenges. First, there is the issue of unobservable time-constant heterogeneity that impact trade openness and outcome variables. This unobserved heterogeneity is invariant to time and typically consists of qualitative traits that are unobservable, difficult to measure, or have not been quantified due to their qualitative nature. If not accounted for, this might exaggerate the trade openness effect. The benefit of panel data analysis over cross-sectional data analysis is that it can account for this unobservable heterogeneity. Fixed effect (FE) and random effect (RE) estimation methods are often used to account for unobserved heterogeneity. The FE approach allows correlation between ϑ_i and the other factors (CV_{it}). It handles unobserved heterogeneity as an unobserved random variable that is associated with CV_{it}, therefore correcting for individual heterogeneity and permitting variations within nations over time. As a result, it has been widely used for linear panel models. In contrast, a random effect method models the distributions of the country-specific effect and a fixed effect for which the distribution is completely unspecified. The RE assumes strict exogeneity (absence of correlation) between ϑ_i and explanatory factors and measures the effect of time-invariant explanatory variables (Wooldridge, 2012). Principal shortcoming of the RE model is its restrictive assumption that random effects are independent of variables.

The second estimation challenge is the existence of time-variant unobserved factors that may alter our outcome variables of interest. One common approach in addressing the endogeneity issue is the use of IV estimation approach. This is due to the fact that IVs are used to eliminate correlations between the error term and endogenous independent variables. To undertake IV estimation, instruments are needed in a two-step procedure that ensures that the instruments are uncorrelated with the error term but sufficiently strongly correlated with TO after controlling for all other independent variables. In the first step, each endogenous TO variable is regressed on all of the model's exogenous variables (including the excluded instruments). In the second step, the original equation is estimated using the predicted values for each endogenous variable derived from the first stage regression.

Although it is difficult to identify a 'relevant' and a 'strong' instrument (which will be explored in the next section), using a 'bad instrument' can detrimentally affect the performance of the selected econometric model (Bettis et al., 2014). Taking cues from existing research (Dithmer & Abdulai, 2017), I used sufficiently lagged values of endogenous TO variables as instruments to guarantee that FNS is caused by the explanatory variables (and not vice versa). These variables were considered as instruments because at the beginning of the current year, the values of the previous years are all known and can be considered as exogenous.

Instruments for $TO_{i,t}$ are obtained using the following reduced form equation:

$$TO_{i,t} = \pi_0 + \pi_1 z_1 + \pi\boldsymbol{X} + v_{it} \qquad (1)$$

Where π_k is the estimated parameter coefficients; CV is the vector of all the explanatory variables; z_k are our instruments. The selection of these instruments is on the basis that they are exogenous and are strongly correlated with the endogenous regressor, in this case $TO_{i,t}$ and uncorrelated with the error term, ε_{it}, in Equation (1).

The instruments used should be both valid (that is, orthogonal to the errors) and relevant (that is, appropriately associated with the endogenous regressors). To guarantee that the model is not misspecified, I run some specification tests, which are detailed below.

Tests of underidentification, relevance and exogeneity

To begin, it should be recognized that the regression equation must be identified before it can be estimated. This indicates that the rank criterion must be satisfied, i.e. the regressor matrix, including the instruments, has full column rank. Simply put, the rank condition implies non-zero canonical correlations between groups of endogenous regressors and excluded instruments. (Baum et al., 2007). To test for underidentification, I use the Kleibergen-Paap rk Lagrange multiplier (LM) test, which may be thought of as a non-i.i.d. error generalization of Anderson's (1951) canonical correlations test (proving the null that the smallest canonical correlation is zero) (Kleibergen & Paap, 2006). Rejecting the null hypothesis that the equation is underidentified suggests that the matrix has full column rank, indicating that the model is identified (Baum et al., 2007).

Second, the endogenous regressors should be relevant predictors of the variable of interest, in this instance, FNS. This condition necessitates a strong connection between the endogenous regressor and the instrument. When this correlation is significant, the instrument is described as 'strong.' When there is a weak correlation, the instrument is said to be 'weak,' and when there is no correlation, the instrument is said to be 'irrelevant.' Even if underidentification is rejected, weak instruments pose a major threat because they produce an asymptotic bias that grows in proportion to the instrument's weakness. In other words, the conventional t-statistic and confidence intervals are no longer reliable. The significance of the excluded instruments in the first-stage F-statistics developed by (Stock et al., 2002) may be used to examine the correlation of the instruments with the endogenous regressors (Baum et al., 2007). I test the null hypothesis that the coefficients of the endogenous regressors in the main equation are all zero. I also report the Kleibergen-Paap rk Wald F statistic and compare it to the crucial values of (Stock et al., 2002) F-statistic to test for weak identification. I test the null hypothesis that the maximum bias in the coefficient estimates for possibly endogenous regressors was more than 10, 15, or 20%, indicating that the estimator was only weakly identified. The rejection of the null shows that there is no weak-instruments problem.

Third, I use Hansen (1982) J-test of overidentifying restrictions to evaluate the validity of the orthogonality conditions. If the equation is overidentified (i.e., the number of excluded instruments exceeds the number of included endogenous regressors), the "Hansen test" examines the null of joint validity of the moment conditions (full set of instruments), which is equivalent to testing the covariate exogeneity. It specifically examines whether the vector of empirical moments is distributed randomly around zero. The Hansen J-test is robust to heteroskedasticity and within-group correlation for all instruments. The null hypothesis that the instruments are valid, i.e. uncorrelated with the error term, and that the omitted instruments are accurately excluded from the estimated equation should not be rejected (Baum et al., 2007). In my case, the equation is exactly identified (i.e. the number of excluded instruments equals the number of included endogenous regressors), and as a result, the p value for the Hansen J-test is not reported.

4.0 Results and Discussion

This is followed by a trend analysis of the FNS status of the full panel, and agri-food trade openness status in sub-sections 4.2 and 4.3 respectively. Empirical findings of the panel estimations are thereafter divided into full panel, and income groups (i.e. LI, LMI, UMI, and HI countries) in sub-section 4.4. This categorization is necessary in order to capture the intrinsic distinctions across income groups. All specification tests completed support the model specification as shown in Table 3 in the appendix. The Kleibergen-Paap rk LM statistic test rejects the null hypothesis that the equation is underidentified, suggesting that the matrix has full column rank, indicating that the model is identified. The (Stock et al., 2002) first stage regression F-test also rejects the null hypothesis that the coefficients of the structural equation's endogenous regressors are jointly equal to zero, demonstrating the strength of the structural equation's endogenous regressors. The Kleibergen-Paap rk Wald F-statistic reveals that the maximum bias in the coefficient estimations for possibly endogenous regressors exceeds 10%, demonstrating the absence of weak identification. Finally, the Hansen (1982) J-test of overidentifying restrictions was not reported because the equations were exactly identified.

4.1 Descriptive statistics

Table 5 presents the descriptive statistics of the variables aimed to illustrate the variables' characteristics. Given the possibility of multicollinearity concerns in the models developed, which might impair the reliability of estimate outcomes, a correlation analysis was performed between independent variables. According to the correlation analysis results in Table 6, the vast majority of absolute values of the Pearson correlation coefficients between the independent variables were less than 0.6, indicating that there was no strong multicollinearity in the models.

Table 5: Descriptive statistics of the variables for the full sample of countries

Variables	**N**	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**
Prevalence of obesity among adults (PoO)	1,824	15.582	8.712	0.000	37.300
Prevalence of anaemia among pregnant women (PoA)	2,052	29.879	14.023	0.000	61.500
Prevalence of undernourishment (PoU)	2,052	10.182	10.593	2.500	67.500
Agricultural trade openness (afto)	2,052	7.733	4.678	0.843	32.407
Cereals trade openness (cto)	2,052	0.987	1.003	0.018	8.818
Fresh Fruits and Vegetables trade openness (ffvto)	2,052	1.130	1.134	0.018	10.607
Tropical commodities trade openness (tcto)	2,052	1.577	1.970	0.060	15.296
GDP per capita (gdpperc)	2,052	20,469.88	20,052.88	0	120,647.80
Rural population (rp)	2,052	39.688	20.679	1.999	86.053
Arable land (al)	2,052	0.257	0.260	0.004	1.976
Agricultural productivity (ap)	2,052	192117.100	138948.200	0.000	647489.000
GDP growth (gdpgr)	2,052	3.638	3.809	-20.599	34.466
Population growth (pg)	2,052	1.285	1.366	-3.848	15.177
Intensity of natural disasters (ind)	2,052	0.014	0.064	0.000	1.414
Armed conflict (ac)	2,052	0.149	0.405	0.000	2.000
Inflation (ind)	2,052	4.792	6.476	-9.616	108.897
Foreign Direct Investment (fdi)	2,052	5.727	20.519	-57.605	449.083
Urbanization (ur)	2,052	60.312	20.679	13.947	98.001

Table 6: Correlation Matrix of the independent variables

	afto	cto	Ffvto	tcto	gdpperc	rp	al	ap	gdpgr	pg	ind	ac	infl	fdi
afto	1.000													
cto	0.526	1.000												
ffvto	0.608	0.070	1.000											
tcto	0.627	0.359	0.241	1.000										
gdpperc	-0.284	-0.427	-0.105	-0.353	1.000									
rp	0.227	0.367	-0.005	0.485	-0.575	1.000								
al	-0.033	0.040	-0.137	-0.120	0.031	-0.148	1.000							
ap	-0.154	-0.325	0.039	-0.359	0.526	-0.508	0.072	1.000						
gdpgr	-0.013	0.083	-0.047	0.109	-0.227	0.235	0.025	-0.180	1.000					
pg	-0.010	0.199	-0.035	0.227	-0.138	0.230	-0.196	-0.275	0.152	1.000				
ind	0.006	0.050	0.003	-0.001	-0.095	0.115	-0.047	-0.128	-0.007	0.027	1.000			
ac	-0.226	-0.040	-0.158	-0.062	-0.125	0.112	-0.006	-0.038	0.041	0.081	0.060	1.000		
infl	0.023	0.128	-0.042	0.076	-0.259	0.172	0.048	-0.190	0.076	0.063	0.023	0.182	1.000	
fdi	0.023	-0.028	0.030	-0.046	0.101	-0.107	-0.066	-0.037	0.002	-0.025	0.016	-0.049	-0.036	1.000

4.2 Trends in Food and Nutrition Security

A descriptive analysis of the evolving characteristics of FNS status in 114 countries divided into four income categories was conducted, focusing on the "access" and "utilization" dimensions of food security, which are denoted by the PoU, PoA, and PoO. Figures 3, 4 and 5 depict the evolutionary trends in the prevalence of undernourishment, anaemia, and obesity from 2001 to 2018.

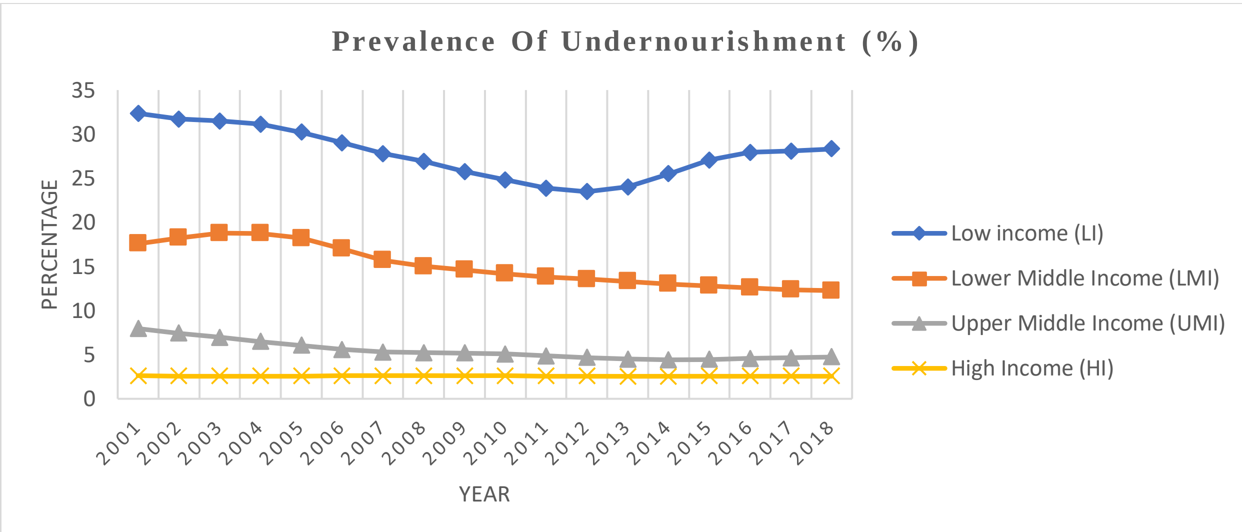


Figure 3: Prevalence of Undernourishment (%)

Source: Own weighted average calculation based on WDI

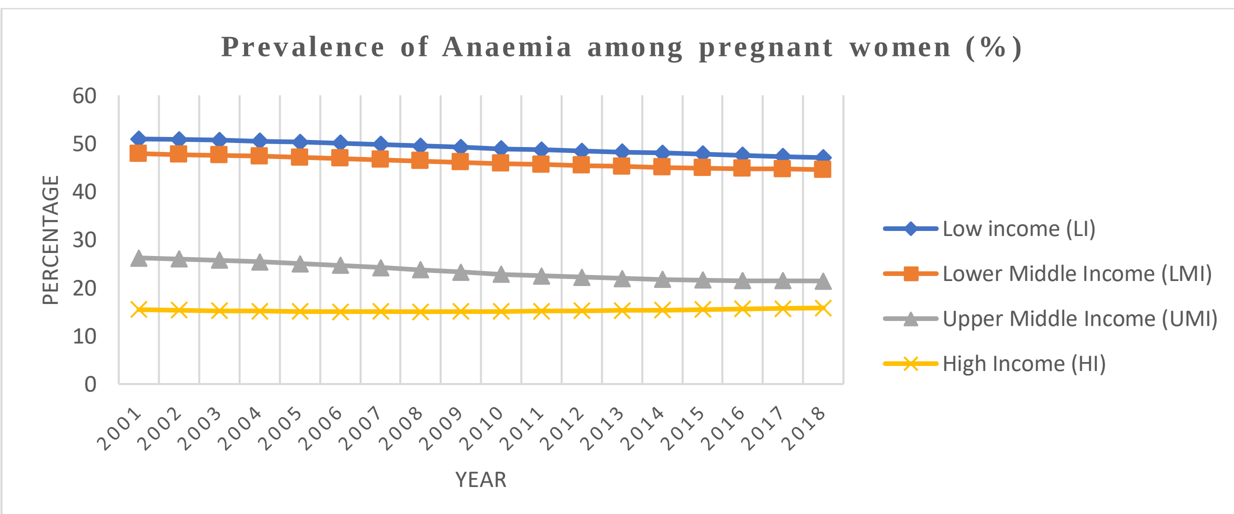


Figure 4: Prevalence of Anaemia among pregnant women (%)

Source: Own weighted average calculation based on WDI

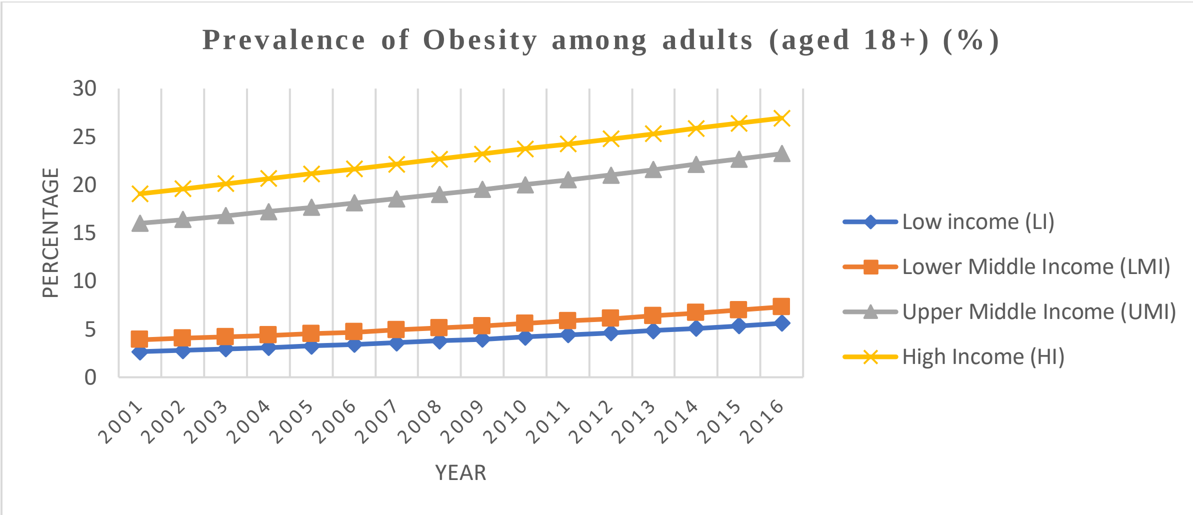


Figure 5: Prevalence of Obesity among adults (aged 18+) (%)

Source: Own weighted average calculation based on WHO

PoU has been reducing from 2001 to 2012 in LMICs as shown in figure 3. The reduction is more prominent in LI countries. However, in 2013-2014, there was drastic increase from 2% to 6% in LI countries. HI countries have had a low prevalence of undernourishment of 2.5% over the 18-year period observed. As can be seen in Figure 4, the PoA has not changed significantly over the 18-year period. However, LMICs are experiencing the highest prevalence, while UMI and HI countries have low prevalence. All income groups of the world have experienced an increase in PoO as shown in figure 3. These patterns, however, show some variation. HI countries have the higher PoO, but the percentage increase ranges from 2-3 percent. LMICs have lower prevalence of obesity but have a higher percentage increase ranging from 4-5 percent over the 18-year study period. The growth in obesity has been ascribed to the convergence of urbanization and higher incomes, the easing of imports of processed foods, and Foreign and local investment in processing after liberalization and privatization (Reardon et al., 2019).

4.3 Trends in Agri-food Trade

Figures 6 to 9 shows the evolution of agri-food trade openness in 114 countries divided into four income groups over the period 2001 - 2018.

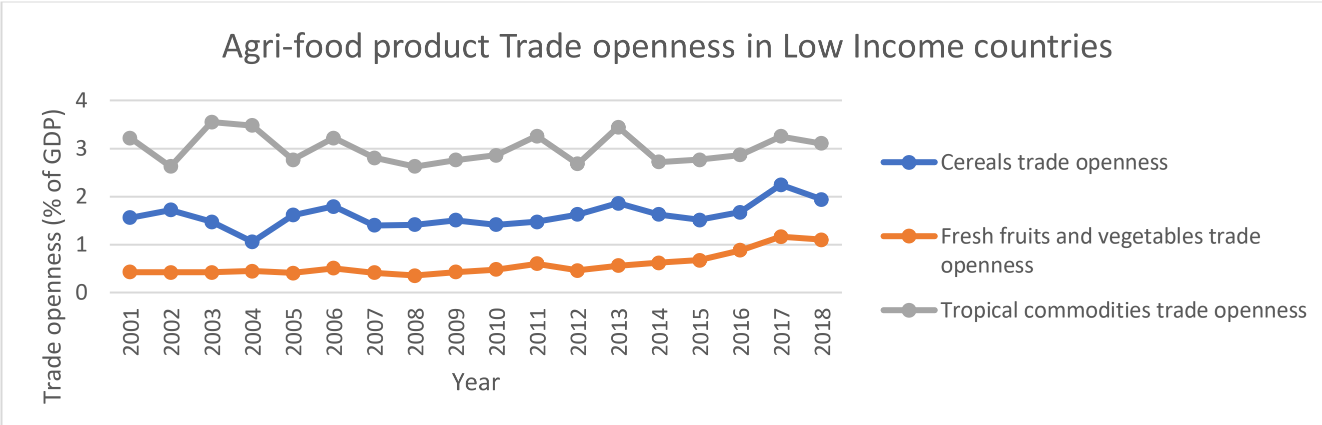


Figure 6: Agri-food product Trade openness in Low Income countries

Source: Own weighted average calculation based on FAOSTAT data

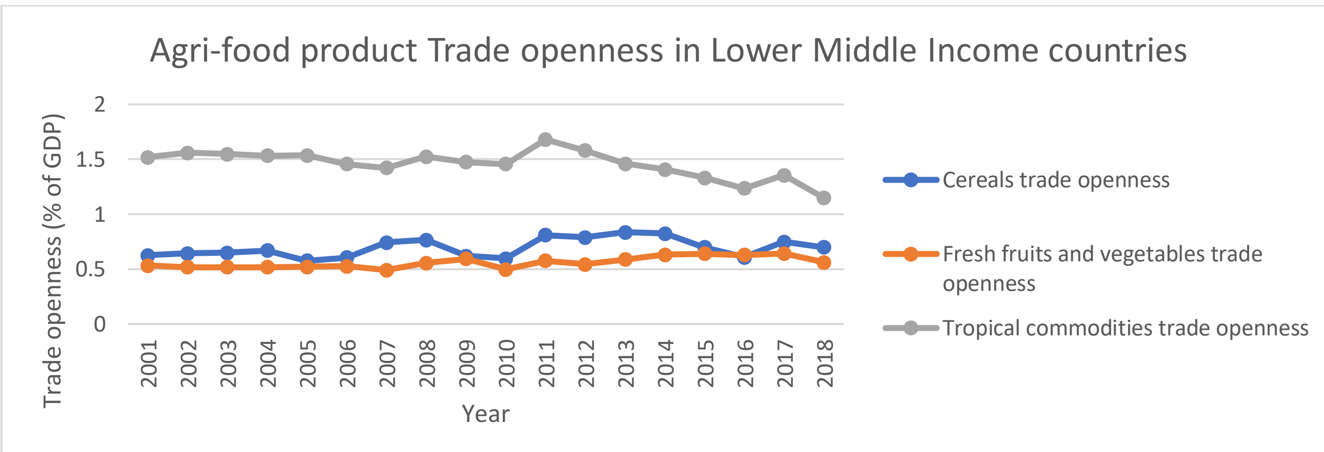
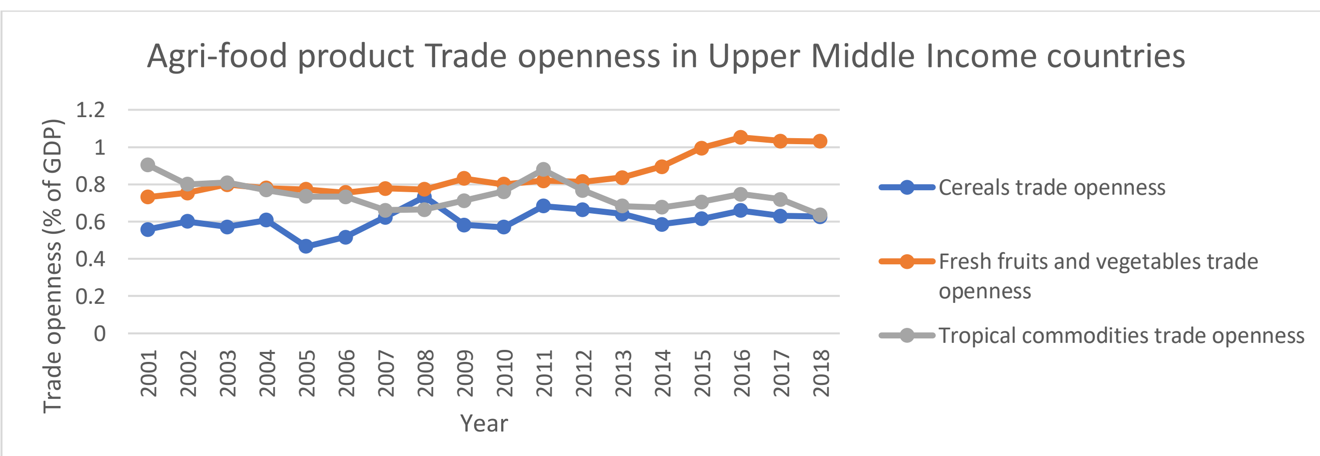


Figure 7: Agri-food product Trade openness in Lower Middle-Income countries

Source: Own weighted average calculation based on FAOSTAT data



Source: Own weighted average calculation based on FAOSTAT data

Figure 8: Agri-food product Trade openness in Upper Middle-Income countries

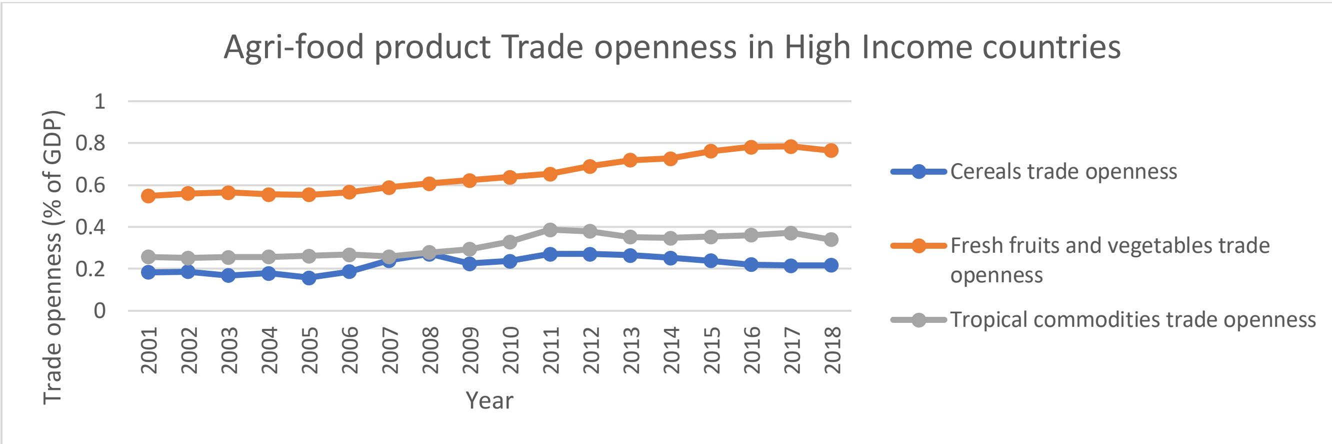


Figure 9: Agri-food product Trade openness in High Income countries

SOURCE: Own weighted average calculation based on FAOSTAT data

From figures 6 and 7 above, LI and LMI countries are more open to trade in tropical commodities. The primary commodities in terms of export volume are cocoa, coffee, tea, cotton, sugarcane, tobacco, and palm oil. The majority of tropical commodity value chains are export-oriented, with minimal local processing. Cereals are the second important agri-food products for LI and LMI countries, as they are largely intended for the domestic market. Exports of cereals are mostly from domestic production and product differentiation is low, hence, the value chains for cereals exports are also not differentiated. Domestic cereal markets in Africa have been substantially liberalized, but there is still a significant degree of state interference in international cereal trade, with sometimes unpredictable policies such as abrupt export prohibitions (Baffes et al., 2019; Minot, 2010). Fresh fruits and vegetables (FFV) are the least traded commodities in LI and LMI countries. While these commodities are regarded as "high-value" products with high and relatively consistent foreign exchange earnings (Van den Broeck & Maertens, 2016), the value chains are highly consolidated, with a few big export manufacturers dominating the chains, and there is a high degree of vertical coordination. International trade in FFV is heavily controlled by increasingly strict public and private standards (Beghin et al., 2017; Fiankor et al., 2019; Henson & Humphrey, 2010; Swinnen, 2016).

On the contrary, in figures 8 and 9, FFV is the most important agri-food trade product for UMI and HI countries, followed by tropical commodities and lastly Cereals. This agrees with Bennett's Law (Bennett, 1954) who forecasted a shift toward a larger proportion of non-staples in the diet as incomes grow. At the system level, this indicates that with development (as measured by GDP per capita), one should anticipate disproportionate expansion in non-staple supply chains such as vegetables and fruit, meat and fish, dairy, and edible oils (Reardon et al., 2019).

4.4 Panel Data Estimation Results Using the 2SLS-IV FE approach

The results of the impact of trade openness on PoU, PoA, and PoO for the full panel of 114 selected countries is shown in Table 7, while the results for the income groups are presented in Tables 8 and 9. Robust standard errors were used, and year dummies were included in all regressions. Generally, while most studies do find positive effects of trade, especially on calory supply, the results of this thesis showed that agricultural trade openness has a statistically significant negative impact on food and nutrition security indicators (i.e. PoU, PoA, and PoO) on average. Results from previous studies could be attributed to the different time coverage, while this study covered a recent period (2001 to 2018). This was an era that saw rapid globalization and international trade crises occurring at the same time. Also, lagged values of endogenous trade openness variables were employed as instruments to guarantee that food and nutrition security is caused by the explanatory variables (and not vice versa). The instrument is valid as revealed by the model specification tests, and thus serves as a better control for the endogeneity of trade openness.

Table 7: Trade openness and Prevalence of Undernourishment, Anaemia and Obesity (Full sample)

VARIABLES	PoU (1) (Baseline model)[1]	PoU (2) (Alternative model)[2]	PoA (3) (Baseline model)	PoA (4) (Alternative model)	PoO (5) (Baseline model)	PoO (6) (Alternative model)
Agricultural trade openness	0.398***		0.100***		0.040***	
	(0.090)		(0.018)		(0.015)	
Cereals trade openness		0.557		0.042		-0.207*
		(0.343)		(0.067)		(0.112)
Fresh Fruits and Vegetables trade openness		0.211		0.184*		0.129
		(0.259)		(0.096)		(0.102)
Tropical commodities trade openness		0.350***		0.160***		0.065*
		(0.120)		(0.038)		(0.036)
GDP per capita	-7.222***	-7.432***	-2.405***	-2.426***	-0.862***	-1.001***
	(0.767)	(0.782)	(0.302)	(0.307)	(0.266)	(0.278)
Rural population	0.272***	0.294***	0.057***	0.064***		
	(0.049)	(0.048)	(0.019)	(0.018)		
Arable land	5.419**	6.748***	-0.207	0.195	-3.530***	-3.132***
	(2.293)	(2.450)	(0.998)	(0.990)	(0.941)	(0.965)
Agricultural productivity	-0.060	-0.040	-0.017	-0.012	0.044	0.044
	(0.046)	(0.045)	(0.040)	(0.037)	(0.040)	(0.041)
GDP growth	0.062**	0.054*	0.024***	0.024***	-0.006	-0.004
	(0.028)	(0.029)	(0.007)	(0.007)	(0.008)	(0.008)
Population growth	0.679***	0.656***	0.034	0.032	-0.038	-0.033
	(0.083)	(0.084)	(0.029)	(0.030)	(0.047)	(0.048)
Intensity of natural disasters	0.423	0.434	-0.431	-0.423	0.045	0.095
	(1.038)	(1.141)	(0.331)	(0.334)	(0.324)	(0.327)
Armed conflict	0.497	0.613*	0.027	0.059	0.032	0.056
	(0.314)	(0.318)	(0.115)	(0.116)	(0.110)	(0.110)
Inflation	0.056	0.058	-0.006	-0.005	-0.008	-0.006
	(0.044)	(0.045)	(0.005)	(0.005)	(0.006)	(0.006)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,938	1,938	1,938	1,938	1,710	1,710
Number of countries	114	114	114	114	114	114
R-squared	0.302	0.273	0.497	0.496	0.832	0.833

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[1] The baseline models show the impact of Agricultural trade openness on the dependent variables (PoU, PoA, and PoO)

[2] The alternative models show the impact of Cereals, fresh fruits and vegetables, and tropical commodities trade openness on the dependent variables (PoU, PoA, and PoO)

Table 7 presents the estimation results for the impact of trade openness on the prevalence of undernourishment, Anaemia and Obesity (for the full sample). Starting with the baseline and alternative model results for PoU in Column 1, a 1% increase in *agricultural trade openness* is estimated to increase PoU by 0.4% points. This is in line with Mary, (2019) who finds that a 10% increase in food trade openness would increase PoU by 6%. Marson et al., (2022) found that a 1% increase in total trade openness decreases the prevalence of undernourishment by around 0.12 points. Their result might be applicable for total trade, but not agricultural trade. For the alternative model in Column 2, the coefficient for *tropical commodities trade openness* was found to be statistically significant, where a 1% increase in *tropical commodities trade openness* is estimated to increase PoU by 0.35% points. Column 3 shows the results for PoA where a 1% increase in *agricultural trade openness* is estimated to increase PoA by 0.1% points. For the alternative models in Column 4, the coefficients for *fresh fruits and vegetables*, and *tropical commodities trade openness* were found to be statistically significant, implying that a 1% increase is estimated to an increase in PoA by 0.18% and 0.16% points respectively. In column 5, a 1% increase in *agricultural trade openness* is estimated to increase PoO by 0.04% points. For the alternative models in Column 6, a 1% increase in *cereals trade openness* is estimated to decrease PoO by 0.21% points, while a percent increase in *tropical commodities trade openness* would increase PoO by 0.07% points. This result lends credence to the theory that agricultural trade liberalization (particularly tropical commodities) is one of the primary reasons for worldwide obesity growth (Clark et al., 2012; Hawkes, 2006; B. M. Popkin, 2006; Thow & Hawkes, 2009).

In line with expectations, the coefficients for *GDP per capita* is negative and statistically significant in the baseline and alternative models, suggesting that economic growth reduces PoU, PoA and PoO. The coefficient for *rural population* is positive and significant for PoU and PoA while the coefficient of *population growth* is positive and statistically significant for PoU, implying that demographic pressure affects per capita food supplies and increases PoU. In the case of *natural disasters* and *armed conflict*, statistical insignificance may result from the local impact of some of these occurrences, although the dependent variables are at the national level (Marson et al., 2022). The coefficients of the remaining variables are not statistically significant.

Table 8: Trade openness and Prevalence of Undernourishment, Anaemia and Obesity (Income group – Baseline models)

VARIABLES	LI			LMI			UMI			HI		
	PoU	PoA	PoO	PoU	PoA	PoO	PoU	PoA	PoO	PoU	PoA	PoO
Agricultural trade openness	0.424**	0.077	-0.051**	0.553***	0.118***	0.036*	-0.134	0.121***	-0.121**	0.083***	0.042	-0.011
	(0.187)	(0.053)	(0.025)	(0.156)	(0.025)	(0.021)	(0.131)	(0.044)	(0.052)	(0.023)	(0.028)	(0.022)
GDP per capita	-5.062	3.250***	-0.657**	1.366	0.355	-2.881***	-13.537***	-0.027	-0.459	-0.612*	-1.142***	1.365***
	(3.224)	(1.198)	(0.331)	(2.313)	(0.689)	(0.797)	(1.276)	(0.404)	(0.383)	(0.324)	(0.361)	(0.389)
Rural population	0.464*	-0.263**		0.290**	-0.074*		-0.013	-0.188***		0.098***	0.161***	
	(0.276)	(0.108)		(0.119)	(0.043)		(0.071)	(0.029)		(0.023)	(0.035)	
Arable land	-10.597	-3.781	0.552	23.208*	6.490**	-4.622	7.038	2.953	-12.049***	-2.552***	-6.929***	-5.053***
	(16.045)	(4.194)	(1.301)	(13.197)	(2.741)	(3.324)	(4.328)	(2.566)	(2.483)	(0.501)	(0.815)	(0.779)
Agricultural productivity	-0.870	-0.572	-0.275**	-3.258***	-0.730**	1.233***	1.238**	0.804**	0.495**	-0.022	-0.054***	-0.031*
	(1.908)	(0.395)	(0.109)	(1.068)	(0.305)	(0.388)	(0.597)	(0.317)	(0.226)	(0.018)	(0.018)	(0.018)
GDP growth	-0.013	0.003	0.009*	0.154**	-0.008	0.001	0.004	-0.017	-0.008	-0.000	0.033***	0.012
	(0.082)	(0.016)	(0.005)	(0.064)	(0.014)	(0.017)	(0.040)	(0.011)	(0.011)	(0.009)	(0.010)	(0.007)
Population growth	2.493***	-0.162	-0.016	3.512***	0.906***	0.974***	0.587***	0.207	0.223**	0.297***	-0.019	-0.189***
	(0.910)	(0.195)	(0.055)	(0.645)	(0.205)	(0.179)	(0.222)	(0.148)	(0.091)	(0.042)	(0.027)	(0.034)
Intensity of natural disasters	14.413**	-0.359	-0.346	-2.700	-0.751	0.690	0.994	-0.389	-0.069	0.037	0.056	0.064
	(5.725)	(1.112)	(0.273)	(2.610)	(0.617)	(0.713)	(0.912)	(0.307)	(0.360)	(0.181)	(0.242)	(0.313)
Armed conflict	-0.461	-0.178	0.115*	1.004***	-0.015	-0.042	-0.337	1.397***	-0.053	-0.087	-0.384***	-0.178
	(1.004)	(0.266)	(0.061)	(0.376)	(0.108)	(0.103)	(0.674)	(0.291)	(0.313)	(0.057)	(0.128)	(0.289)
Inflation	-0.196**	-0.007	0.007	0.135***	0.002	0.004	0.008	-0.005	-0.019***	-0.007	-0.009	-0.002
	(0.078)	(0.020)	(0.005)	(0.049)	(0.006)	(0.006)	(0.036)	(0.013)	(0.007)	(0.014)	(0.016)	(0.013)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	153	153	135	578	578	510	510	510	465	680	680	600
Number of countries	9	9	9	34	34	34	30	30	31	40	40	40
R-squared	0.572	0.769	0.971	0.428	0.621	0.735	0.395	0.741	0.906	0.404	0.444	0.952

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8 presents the estimation results for the four income groups (baseline models). Starting with LI countries, a 1% increase in *agricultural trade openness* is estimated to increase PoU by 0.42% points, and decrease PoO by 0.05% points. For LMI countries, a 1% increase in *agricultural trade openness* is estimated to increase PoU by 0.55% points, PoA by 0.12% points, and PoO by 0.04% points. This finding supports the hypothesis that agricultural trade liberalization is a major driver of undernutrition in developing nations (Clapp, 2015; De Schutter, 2011; Díaz-Bonilla, 2015; Diaz-Bonillo, 2013; Gayi, 2007; Matthews, 2014; Singh, 2017; WTO, 2009). The finding also supports the argument that developing countries are not competitive enough to benefit from agricultural trade liberalization, particularly in a situation where substantial farm subsidies in developed countries prevent developing countries from accessing export markets and potential advantages (Bureau et al., 2006; Koning & Pinstrup-Andersen, 2007; Tokarick, 2008; Wise, 2009). For UMI countries, a 1% increase in *agricultural trade openness* is estimated to increase PoA by 0.12% points and decrease PoO by 0.12% points. While for High income countries, a 1% increase in *agricultural trade openness* is estimated to increase PoU by 0.08% points.

Greater food availability is expected to lower food producer prices, which could lower farmers' and rural families' earnings. Similarly, trade advantages may be collected mostly by intermediaries throughout the food chain and may not go to farmers or rural communities. This is particularly true in developing countries because food markets are plagued with imperfection (Sexton et al., 2007).

The coefficients for *GDP per capita* show some variations across the income groups and agri-food product categories: For LI countries, it is positive and significant for PoA, and negative for PoO; for LMI countries, it is negative for PoO; for UMI countries, it is negative for PoU; for HI countries, it is negative and significant for PoU, PoA, and positive for PoO. The coefficient for *rural population* is positive and significant for PoU and PoA for LI, LMI, and HI countries while the coefficient of *population growth* is positive and statistically significant for PoU for all the income categories, implying that demographic pressure which affects per capita food supplies, increases PoU. The coefficient of *urbanization* is positive and statistically significant for UMI and HI countries. The share of *arable land* shows some variations: the coefficients for PoU and PoA are positive and significant for LMI countries, negative and significant for PoO in UMI countries, and negative for PoU, PoA, and PoO in HI countries. The coefficient of *intensity of natural disaster* is positive and statistically significant for PoU in LI countries, while the coefficient of *armed conflict* is positive and significant for PoO in LI countries; positive for PoU in LMI countries, positive for PoA in UMI countries; and negative for PoA in HI countries.

Table 9: Trade openness and Prevalence of Undernourishment, Anaemia and Obesity (Income group – Alternative models)

VARIABLES	**LI**			**LMI**			**UMI**			**HI**		
	PoU	PoA	PoO	PoU	PoA	PoO	PoU	PoA	PoO	PoU	PoA	PoO
Cereals trade openness	0.602	-0.252	0.090	0.579*	0.390***	-0.287**	0.902	0.859***	-0.452	0.284*	-0.552***	-0.723***
	(0.829)	(0.184)	(0.107)	(0.297)	(0.099)	(0.139)	(0.768)	(0.259)	(0.283)	(0.147)	(0.167)	(0.189)
Fresh Fruits and Vegetables trade openness	5.588***	-0.779	-1.968	-1.916***	-0.097	0.498**	0.306	0.170	-0.657***	0.186***	0.059	0.060
	(2.113)	(0.636)	(2.078)	(0.618)	(0.157)	(0.215)	(0.312)	(0.114)	(0.182)	(0.065)	(0.111)	(0.082)
Tropical commodities trade openness	-0.212	0.156**	-0.083	1.088***	0.204***	-0.002	-2.083***	-0.385**	0.367***	0.092	0.320***	0.198***
	(0.318)	(0.079)	(0.209)	(0.184)	(0.053)	(0.048)	(0.366)	(0.171)	(0.104)	(0.074)	(0.079)	(0.060)
GDP per capita	-14.638***	4.410***	1.100	1.675	0.813	-3.688***	-13.415***	0.395	-0.595	-0.506	-1.022***	1.414***
	(4.987)	(1.543)	(1.090)	(2.325)	(0.709)	(0.912)	(1.232)	(0.481)	(0.487)	(0.345)	(0.375)	(0.368)
Rural population	1.097***	-0.324***		0.285***	-0.071		-0.092	-0.210***		0.100***	0.174***	
	(0.361)	(0.118)		(0.107)	(0.044)		(0.076)	(0.030)		(0.024)	(0.035)	
Arable land	5.647	-8.935**	-6.535	16.942	5.720**	-4.675	3.155	0.947	-11.040***	-2.803***	-5.289***	-3.707***
	(18.657)	(4.122)	(13.016)	(13.693)	(2.696)	(3.234)	(5.630)	(2.572)	(2.547)	(0.519)	(0.772)	(0.936)
Agricultural productivity	-1.152	-0.487	0.179	-2.760**	-0.691**	1.354***	1.129*	0.741**	0.565**	-0.022	-0.048**	-0.028
	(2.205)	(0.415)	(0.583)	(1.155)	(0.300)	(0.379)	(0.610)	(0.319)	(0.225)	(0.019)	(0.020)	(0.019)
GDP growth	0.078	-0.003	-0.008	0.143**	-0.014	-0.000	-0.021	-0.025**	-0.007	-0.003	0.027***	0.009
	(0.097)	(0.018)	(0.014)	(0.066)	(0.014)	(0.018)	(0.042)	(0.012)	(0.010)	(0.009)	(0.010)	(0.008)
Population growth	2.238**	0.171	-0.010	4.953***	1.091***	0.946***	0.479**	0.210	0.324***	0.287***	-0.024	-0.185***
	(1.089)	(0.228)	(0.131)	(0.822)	(0.204)	(0.176)	(0.231)	(0.157)	(0.105)	(0.045)	(0.031)	(0.032)
Intensity of natural disasters	15.010***	-0.665	-1.030	-0.831	-0.731	0.648	1.033	-0.327	-0.012	-0.020	0.002	0.028
	(4.665)	(1.222)	(0.910)	(3.290)	(0.600)	(0.747)	(0.873)	(0.329)	(0.340)	(0.181)	(0.238)	(0.313)
Armed conflict	0.130	-0.232	0.000	0.928**	-0.023	-0.027	-0.420	1.411***	-0.024	-0.072	-0.315***	-0.129
	(0.959)	(0.250)	(0.170)	(0.374)	(0.110)	(0.106)	(0.692)	(0.283)	(0.295)	(0.047)	(0.117)	(0.294)
Inflation	-0.181**	0.002	0.012	0.165***	0.001	0.005	0.026	0.001	-0.025***	-0.014	-0.018	-0.007
	(0.080)	(0.021)	(0.015)	(0.046)	(0.007)	(0.006)	(0.035)	(0.013)	(0.006)	(0.014)	(0.016)	(0.011)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	153	153	135	578	578	510	510	510	465	680	680	600
Number of countries	9	9	9	34	34	34	30	30	31	40	40	40
R-squared	0.522	0.759	0.790	0.403	0.618	0.731	0.422	0.740	0.908	0.396	0.468	0.953

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9 shows the estimation results for the four income groups and distinguishing between trade in different agricultural produce (Alternative models). Starting with LI countries, a 1% increase in *tropical commodities trade openness* is estimated to increase PoA by 0.16% points, while a 1% increase in *fresh fruits and vegetable trade openness* is estimated to increase PoU by 5.6% points. According to Van den Broeck & Maertens (2016), smallholder farmers are believed to be phased out of the horticulture export chain because large export companies prefer to work with farmers who have greater area and labor available for export production. The transition from contract farming to vertically integrated agriculture is believed to have drastically reduced the share of produce sourced from smallholder farmers, For example, the share of Asparagus sourced from smallholder farmers in Senegal reduced from 95% in 2000 to 29% in 2018, while the share of Pineapple sourced from smallholder farmers in Ghana reduced from 45% in 2006 to 5% in 2015 (Maertens & Fabry, 2019).

For LMI countries, a 1% increase in *cereals trade openness* is estimated to increase PoU and PoA by 0.58% and 0.39% points respectively, and decrease PoO by 0.29% points. A 1% increase in *tropical commodities trade openness* is estimated to increase PoU and PoA by 1.1% and 0.2% points respectively. However, a 1% increase in *fresh fruits and vegetable trade openness* is estimated to decrease PoU by 1.92% points. This finding agrees with that of Chege et al., 2015 which revealed that when smallholder farmers in developing countries supply vegetables to supermarkets, a large and positive net effect on all nutritional outcomes was achieved, particularly energy, iron and zinc consumption. However, it was also revealed that a 1% increase in *fresh fruits and vegetable trade openness* is estimated to increase PoO by 0.5% points. This is comparable with the finding of Qaim (2017) which revealed that supermarkets contribute to increased obesity rates among adult customers in Kenya. Shopping in supermarkets, in particular, raised BMI by 1.7 and the likelihood of being overweight or obese by 13%.

For UMI countries, a 1% increase in the coefficient of *cereals trade openness* is estimated to increase PoA by 0.86% points, while a 1% increase in the coefficient of *fresh fruits and vegetable trade openness* is estimated to decrease PoO by 0.66% points. However, a 1% increase in *tropical commodities trade openness* is estimated to reduce PoU and PoA by 2.08% and 0.39% points respectively, while it is estimated to increase PoO by 0.37% points.

For HI countries, a 1% increase in *cereals trade openness* is estimated to increase PoU by 0.28% points, and decrease PoA and PoO by 0.55% and 0.72% points respectively. However, it was revealed that a 1% increase in *fresh fruits and vegetable trade openness* is estimated to increase PoU by 0.19% points, while a 1% increase in *tropical commodities trade openness* is estimated to increase PoA and PoO by 0.32% and 0.20% points.

Similar to the baseline models, the coefficients for *GDP per capita* shows some variations across the income groups and agri-food product categories: For LI countries, it is negative and significant for PoU, and positive for PoA; for LMI countries, it is negative for PoO; for UMI countries, it is negative for PoU; for HI countries, it is negative and significant for PoA, and positive for PoO. The coefficient for *rural population* shows some variations as well: For LI countries, it is positive and significant for PoU and negative for PoA; for LMI countries, it is positive and significant for PoU; for UMI countries, it is negative for PoA; for HI countries, it is positive for PoU and PoA. The coefficient of *population growth* is positive and statistically significant for PoU for all the income categories, implying that demographic pressure which affects per capita food supplies, increases PoU. The coefficient of *urbanization* is positive and statistically significant for LI and UMI countries. The share of *arable land* shows some variations: For LI countries, it is negative and significant for PoU; for LMI countries, it is positive and significant for PoA; for UMI countries, it is negative for PoO; for HI countries, it is positive for PoU, PoA and PoO. The coefficient of *intensity of natural disaster* is positive and statistically significant for PoU in LI countries, while the coefficient of *armed conflict* is positive for PoU in LMI countries, positive for PoA in UMI countries; and negative for PoA in HI countries.

4.5 Research limitations

The findings of this study must be viewed in light of some limitations. The most significant limitation is the difficulty in finding instruments that satisfy the relevance and exogeneity requirements. Lagged values of trade openness were utilized as instruments for this thesis. Rossi (2014) cautions against using IV-based regression if only lagged values are considered "instruments," arguing that this practice cannot be completely justified from an econometric standpoint. However, the tests of relevance and exogeneity employed in this thesis revealed that the instruments are valid and can be employed.

Also, due to time constraints, I was unable to perform robustness tests to determine if my findings were sensitive to sample composition. The findings of this thesis may also be influenced by the exceptional performance of some countries. Consequently, excluding or including these countries may show the effect of the change in the estimated parameters.

Lastly, according to FAO (2003), analysis of trade liberalization should include whether net food-importing countries are impacted differently by liberalization. This is to be anticipated, given that this group of countries should be more sensitive to changes in trade policy and the resulting changes in global and local prices. Twenty out of the thirty-one net food-importing countries were contained in the analyzed panel dataset (Botswana, Côte d'Ivoire, Cuba, Dominican Republic, Egypt, El Salvador, Eswatini, Gabon, Honduras, Jamaica, Jordan, Kenya, Mauritius, Namibia, Pakistan, Peru, Senegal, Sri Lanka, Tunisia, and Venezuela), with the remaining 12 countries not included due to data unavailability (Antigua and Barbuda, Barbados, Dominica, Grenada, Maldives, Mongolia, Morocco, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Samoa, and Trinidad and Tobago).

5.0 Conclusion and policy implications

The second SDG aims to eradicate hunger and malnutrition by 2030. However, progress is slow, and trade liberalization has often been blamed for undernutrition, micronutrient deficiencies, and obesity in low and middle-income nations. Food systems are expected to provide food and nutrition security for a global population that is predicted to reach almost 10 billion by the mid-century. The problem with today's food systems is that they are no longer aligned with changing global objectives, and they have a number of interconnected vulnerabilities that are driving the current nutrition crisis and limiting their potential to supply everyone with healthy, sustainable meals. In terms of research and policy, food and nutrition security get less attention than poverty, and only a few studies explicitly examine the impact of trade policy on food and nutrition security, providing mixed evidence.

In this thesis, new evidence is provided which identifies the major determinants of food and nutrition security. Also, the question of whether or not trade openness improves food and nutrition security was examined. Moreover, studies on the nutritional implications of food trade tend to focus on a single aspect of nutrition (usually calorie supply). While this area of study gives valuable insights into the issue of nutrition, this thesis tried to take a broader perspective and focused also on the triple burden of malnutrition - undernutrition, micronutrient deficiencies and obesity - as indicated by prevalence of undernourishment (PoU), prevalence of anaemia among pregnant women (PoA), and Prevalence of obesity among adults (PoO). Also, emphasis was placed on agri-food product trade, specifically, on cereals, fresh fruits and vegetables, and tropical commodities trade.

Answers to the research questions are derived from empirical results of the Two-stage Least Square (2SLS) Instrumental Variable estimations.

What is the impact of agricultural trade openness on the prevalence of undernourishment, micronutrient deficiencies and obesity?

I discovered that agricultural trade openness has a statistically significant negative impact on food and nutrition security indicators (i.e. PoU, PoA, and PoO) on average, leading me to conclude that the costs of agricultural trade exceed the benefits when the goal is to achieve national level food security. While most studies do find positive effects of trade, especially on calory supply, this thesis agrees with the literature that agricultural trade liberalization is a major driver of global undernutrition and micronutrient deficiencies in most developing countries as a result of trade distorting policy measures of developed countries. Also, trade liberalization has been accused of driving overweight and obesity through the increased supply and consumption changes towards unhealthy processed foods in all regions of the world.

Is this impact different across trade in specific agri-food products?

For the full sample of countries, my results reveal that while Cereals trade openness leads to a decrease in PoO, and trade in fresh fruits and vegetables leads to an increase in PoA, trade in tropical commodities, however, has the most statistically significant negative net impact on PoU, PoA, and PoO. The result reveals that increased intake of tropical commodities such as sugar, oils, and fats via processed meals is an important driver of increasing rate of obesity in developing and developed countries.

Is this impact different across low-, middle-, and high-income countries?

I found that agricultural trade openness also has a statistically significant negative impact on PoU and PoA, particularly for LMICs, which leads me to conclude that developing countries are not competitive enough to benefit from agricultural trade liberalization, and may restrict food trade openness as a response to price volatility in the international markets.

For LI countries, agricultural trade openness increases PoU but decreases PoO; for LMI countries, it increases PoU, PoA, and PoO. A possible explanation for this is that; in a global market dominated by wealthy nations or a small number of advanced developing nations, liberalization results in an influx of inexpensive imports that undermines domestic producers. Employment growth in increasing areas of the domestic economy is often insufficient to accommodate new entrants, much alone those displaced from sustainable farming. The outcome is often a drop in rural poor livelihoods, a fall in food security, and an increase in national food dependence. It is possible that poor urban consumers would profit from reduced food prices, but it is unlikely that the LMICs as a whole will gain from this trade-off. For UMI countries, agricultural trade openness increases PoA but decreases PoO, while for HI countries, it increases PoU.

Regarding the different agri-food products in the income categories, my findings reveals that: for LI countries, fresh fruits and vegetables increases PoU, while tropical commodities increases PoA; for LMI countries, cereals increases PoU and PoA, but decreases PoO, fresh fruits and vegetables decreases PoU, but increases PoO, while tropical commodities increases PoU and PoA. For UMI countries, cereals increases PoA, fresh fruits and vegetables decreases PoO, and tropical commodities trade decreases PoU and PoA, but increases PoO; for HI countries, Cereals increases PoU but decreases PoA and PoO, fresh fruits and vegetables increases PoU, and tropical commodities increases PoA and PoO. Economic growth, urbanization, and globalization all contribute to altering lifestyles, which include shifting consumer tastes, purchasing patterns, and eating environment.

Some policy suggestions may be made based on my empirical findings. While the SDGs provide a good chance and framework to provide a better environment to correct for the effects of free trade, my findings suggest that developing countries, especially LMICs may be better off adopting food self-sufficiency and focusing on improving domestic producer efficiency for some time, despite such actions conflicting with World Trade Organization regulations and current agenda. To combat PoU, PoA, and PoO, combined trade, health, and food initiatives must be devised and executed in line with the different agri-food products. Developed countries can contribute to global food security by reducing trade-distorting policies, such as subsidies, import quotas and tariffs, particularly for items of export importance to developing nations. These market access constraints impede the capacity of agricultural exporters from developing countries to implement a food security plan by limiting their opportunities to profit from international trade.

This thesis concludes that the goal of sustainable, nutritious meals for everyone is attainable, but that the transition of food systems will be complicated and challenging, with inevitable winners and losers. This requires strong and daring action from governments and stakeholders in the agri-food industry. Any system as complicated and dynamic as one that is impacted by food supply, distribution, processing, and demand is difficult to modify. Attempting to effect major change in any aspect of a food system has significant economic and political consequences. This is due to the fact that numerous, often contradictory objectives must be evaluated concurrently. This therefore requires a comprehensive study of trade-offs and potential synergies.

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Appendix 1: List of countries selected and utilized for the study

Albania	Cuba	Japan	Poland
Algeria	Cyprus	Jordan	Portugal
Angola	Czech Republic	Kazakhstan	Romania
Argentina	Denmark	Kenya	Russian Federation
Armenia	Dominican Republic	Kyrgyz Republic	Rwanda
Australia	Ecuador	Latvia	Senegal
Austria	Egypt, Arab Rep.	Lesotho	Sierra Leone
Azerbaijan	El Salvador	Lithuania	Slovak Republic
Bangladesh	Estonia	Luxembourg	Slovenia
Belarus	Eswatini	Madagascar	Solomon Islands
Belgium	Finland	Mali	South Africa
Belize	France	Malta	Spain
Benin	Gabon	Mauritius	Sri Lanka
Bolivia (Plurinational State of)	Gambia	Mexico	Sweden
Bosnia and Herzegovina	Germany	Mozambique	Switzerland
Botswana	Ghana	Namibia	Tanzania
Brazil	Greece	Nepal	Thailand
Brunei Darussalam	Guatemala	Netherlands	Timor-Leste
Bulgaria	Haiti	New Zealand	Togo
Burkina Faso	Honduras	Nicaragua	Tunisia
Cameroon	Hungary	Nigeria	Turkey
Canada	Iceland	North Macedonia	Ukraine
Chad	India	Norway	United Arab Emirates
Chile	Indonesia	Oman	United Kingdom
Colombia	Iran, Islamic Rep.	Pakistan	Uruguay
Congo, Rep.	Ireland	Panama	USA
Costa Rica	Israel	Paraguay	Uzbekistan
Cote d'Ivoire	Italy	Peru	
Croatia	Jamaica	Philippines	

Appendix 2: SITC classification codes of the Agri-food products

1889 Fruit and Vegetables
1944 Cereals
Tropical commodities (329 Cottonseed, 331 Oil, cottonseed, 332 Cake, cottonseed, 767 Cotton lint 768 Cotton, carded, combined, 769 Cotton waste, 770 Cotton linter; 661 Cocoa beans, 662 Cocoa paste, 664 Cocoa butter, 665 Cocoa powder and cake; 656 Coffee green, 657 Coffee roasted, 658 Coffee, substitutes containing coffee, 659 Coffee extracts, 660 Coffee husks and skins; Cotton (lint, linter, waste, carded, seed), 160 Maple sugar and syrups; 257 Oil palm, 258 Oil palm kernel; 259 Cake, palm kernel; 157 Sugar beet, confectionery, 161 Sugar crops, 162 Sugar raw centrifugal, 163 Sugar non-centrifugal, 164 Sugar refined, 167 Sugar nes, 168 Sugar confectionery; 667 Tea, 672 Tea mate extracts), 826 Tobacco unmanufactured, 831Tobacco product nes).

Appendix 3: Test of exclusion restrictions: Trade openness (Full sample – Baseline model)

Variables	Coefficient	P value
One-Year Lagged Agricultural trade openness	0.696*** (0.055)	0.000
Observations	1938	
Kleibergen-Paap Wald rk F statistic	158.48	0.000
Kleibergen-Paap rk LM statistic, p value	151.02	0.000
Stock-Yogo weak ID test critical values at 10%	16.38	
Hansen J, p value		n.a

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix 4: Test of exclusion restrictions: Trade openness (Full sample – Alternative model)

Variables	Coefficient	P value
One-Year Lagged Cereals trade openness	0.587*** (0.062)	0.000
One-Year Lagged Fresh Fruits and Vegetables trade openness	0.725*** (0.045)	0.000
One-Year Lagged Tropical commodities trade openness	0.674*** (0.068)	0.000
Observations	1938	
Kleibergen-Paap Wald rk F statistic	30.34	0.000
Kleibergen-Paap rk LM statistic, p value	40.46	0.000
Stock-Yogo weak ID test critical values at 10%	13.91	
Hansen J, p value		n.a

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Personal Declaration

I hereby affirm that I have prepared the present paper self-dependently, and without the use of any other tools, than the ones indicated. All parts of the text, having been taken over verbatim or analogously from published or not published scripts, are indicated as such. The thesis hasn't yet been submitted in the same or similar form, or in extracts within the context of another examination.

Place, date of submission   Student's signature

Trade Openness and the Triple Burden of Malnutrition

Submitted by: Abiola Ajila

One of the most pressing concerns of the twenty-first century is ensuring that the world's population has consistent access to sufficient, affordable, and nutritious food. Liberalization of agricultural trade is often seen as a critical component of economic policies aimed at increasing food security in developed and developing countries. Many, however, contend that freer agricultural trade may not help most developing countries and may exacerbate food insecurity. Little is known empirically regarding the nutritional implications of trade on food security. Using a sample of 114 countries over the period 2001–2018, this thesis provides new empirical evidence and contributes to the literature in three main ways. First, for the global sample of countries, the impact of total agricultural trade openness on the prevalence of undernourishment (PoU), prevalence of anaemia among pregnant women (PoA), and prevalence of obesity among adults (PoO) is estimated. Second, emphasis is placed on agri-food product trade, notably cereals, fresh fruits and vegetables, and tropical commodities trade. Third, the analysis is split up across income groups: High income (HI), Upper middle income (UMI), Lower middle income (LMI), and Low-income countries (LI). Three main conclusions emerge: (a) agricultural trade openness contributes to increase the PoU, PoA, and PoO in all the countries selected; (b) agricultural trade openness contributes to increase the PoU and PoA in Low and middle-income countries (LMICs); (c) trade in tropical commodities contributes to increase PoU, PoA, and PoO in all the countries selected. The findings suggest that developing countries may benefit by embracing food self-sufficiency for a period of time, despite such activities conflicting with World Trade Organization guidelines and the present agenda.

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