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FOOD CONNECTIONS: INTENDED AND UNINTENDED CONSEQUENCES OF TRADE ON FOOD AND NUTRITION SECURITY

PAPER 2

"THE IMPACT OF INTERNATIONAL TRADE ON FOOD AND NUTRITION SECURITY: A LITERATURE REVIEW"

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Outline

1. Introduction

In 2022, 2.4 billion people – i.e., 30% of the world's population – did not have access to nutritious, safe, and sufficient food all year round, of which an estimated 690 to 783 million people faced chronic hunger.[1] Global hunger has been on the rise since 2017, spiked during the COVID-19 outbreak, and remained at this high level in the following year (Figure 1). There are marked regional differences in the prevalence of undernourishment, with the most vulnerable populations concentrated in Sub-Saharan Africa, Southern Asia, and conflict-ridden countries such as Yemen, Haiti, and Syria.[2] In contrast, the shares of the population exposed to severe food security are relatively low in Europe (1.9%), Eastern Asia (1.0%), and North America (0.7%). Overall, it is projected that almost 600 million people will still be facing hunger in 2030, meaning that the sustainable development goal's (SDG) target of Zero Hunger by the end of this decade seems out of reach.

At the same time, there is considerable uncertainty around these estimates given the high number of factors affecting agricultural production and the distribution of food across and within countries. Scholars have identified several risks and threats to global food and nutrition security, which include, but are not limited to, global warming (Huang et al., 2011; Tai et al., 2014; Lesk et al., 2021), biodiversity loss (Tscharntke et al., 2012; Crist et al., 2017), crop diseases (Savary and Willocquet, 2020; Trivellone et al., 2022), political instability (Demarest, 2015; Laber et al., 2023), financial crises (Headey et al., 2010; Manogna et al., 2024), and socio-economic inequalities (Kruger et al., 2006; Ahmed et al., 2009; Elmes, 2016). Furthermore, it has been noted that the state of food and nutrition security can deteriorate due to "the intensification and interaction of conflict, climate extremes and economic slowdowns and downturns, combined with highly unaffordable nutritious foods and growing inequalities" (FAO, IFAD, UNICEF, WFP and WHO, 2023, p. viii). All in all, the interplay between these factors has created a global agri-food system that is vulnerable to different kind of shocks and supply disruptions.

Against this backdrop, what is the role played by agricultural and food trade at global, national, and individual levels? International trade is considered a key determinant of food and nutrition security. In fact, during the last four decades, trade in agricultural goods has increased six-fold, determining the emergence of a truly global food system in which 25% of agricultural production is traded. Food allocation via international trade feeds 2-3 billion people annually and

[1] The State of Food Security and Nutrition 2023 (FAO)
[2] Global Food Security Index 2022 (Economist Intelligence Unit)

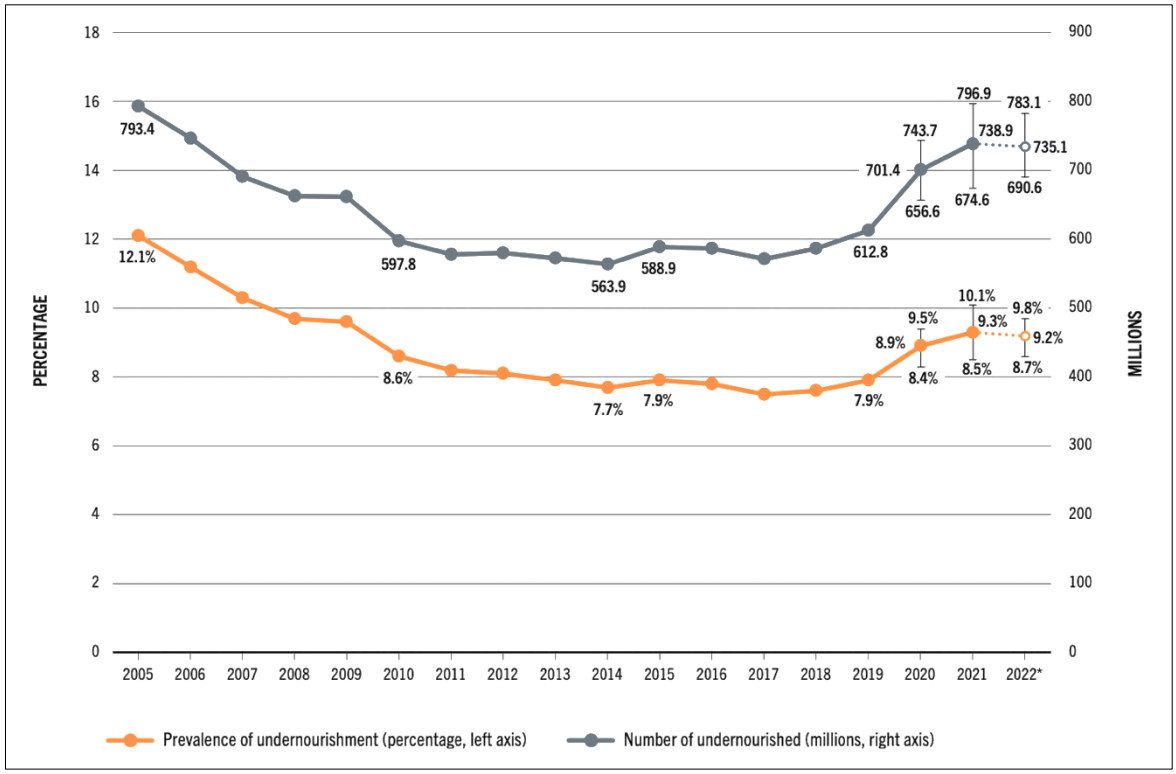

Figure 1. Global hunger estimates and projections. Source: FAO (2023).

food production for export uses around 13% of cropland and pasture worldwide (MacDonald et al., 2015; Ge et al., 2021). As a result, global trade links between countries play a critical role in the transmission of shocks, both natural and man-made. Although there is consensus in the literature that international trade *has* an impact on food and nutrition security, the jury is still out as to *how* it can contribute to (or complicate) the challenge of feeding humanity without putting additional pressure on the environment. The goal of this literature review is to shed light on different concepts, perspectives, and findings regarding the relationship between international trade and food and nutrition security.

The paper proceeds as follows. Section 2 discusses the differences and links between the notions of food security, food sovereignty, and food self-sufficiency, and introduces several forms and measures of malnutrition. Section 3 presents the conflicting views on the effect of international trade (policy) on food and nutrition security. Section 4 focuses on the empirical approaches used to examine the propagation of adverse shocks across the global trading network and describes how countries and individuals are affected by such (extreme) events. Lastly, section 5 proposes a research

agenda based on the gaps in the current literature and highlights the critical issues that need to be addressed in future work.

2. Concepts

Before discussing how international trade affects the distribution of (nutritious) food among countries and individuals, it is key to carefully distinguish between several concepts that are all too often conflated: food security, food sovereignty, and food self-sufficiency. In addition, it is also important to discriminate between different types of malnutrition, because the relationships between international trade, dietary diversity and human health are not straightforward and depend on the particular issue under consideration.

2.1 Food security, sovereignty, and self-sufficiency

Following the widely accepted definition formulated during the World Food Summit of 1996, food security is achieved "when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life."[3] In turn, the concept of food security can be further broken down into four dimensions, which are all seen as essential parts to realize food security objectives: i) the *availability* of sufficient quantities of food of appropriate quality through domestic production or imports; ii) the *access* by individuals to sufficient food for a nutritious diet; iii) a *utilization* that makes the most of the various nutrients in the food, which requires good food preparation, clean water, adequate sanitation and health care; and, iv) the *stability* of the adequate food supply, access, and utilization over time. Although the general aims of food security are not contested, the *means* to achieve these solid and sustainable outcomes for countries and individuals are subject of discussion. While the concept of food security does not specify where the food should come from, advocates of food sovereignty and self-sufficiency are critical about the role of international trade and some reject the notion of 'food from anywhere' (Clapp, 2020).

First, idea of *food sovereignty* emerged from a broad-based movement of activist and scholars in reaction to the negotiated Agreement on Agriculture (AoA) at the World Trade Organization (WTO) during the Uruguay Round. The international trade rules and the commitments to liberalise agricultural markets were perceived as highly asymmetrical, creating an uneven playing field that

[3] Committee on World Food Security (2021). Global Strategic Framework for Food Security & Nutrition.

disadvantaged (farmers in) low-income countries. Since 'food sovereignty' has been used as a catch-all term by different groups, there is little consensus on the exact meaning of the concept. Edelman (2014) notes, for instance, that is unclear who is the sovereign in 'food sovereignty' and which political institutions (at which level) are supposed to administer this policy. For some, 'food sovereignty' is diametrically opposed to the concept of food security while, for others, there is considerable overlap between the two. What is clear, however, is that supporters of 'food sovereignty' prioritize local food production and consumption over international trade.[4] By reducing dependence on world markets, countries and farmers are better insulated from price volatility in world markets and it should also reduce the environmental footprint of agriculture. According to Noll and Murdock (2020), the concepts of food security and food sovereignty are not necessarily in conflict, but they argue that focusing solely on food supply while neglecting concerns around autonomy (for producers and consumers) may have unintended consequences.

Second, *food self-sufficiency* is defined by the FAO (1999) as "the extent to which a country can satisfy its food needs from its own domestic production." It is still possible for a self-sufficient country to engage in agricultural trade because the key point is that a country's *production capacity* exceeds domestic consumption, which does not mean that specific foodstuffs can no longer be imported (Clapp, 2017). Following this definition, scholars have shown that a large majority of countries are in calorie deficit (Puma et al., 2015) and that most countries produce less than 2500 kcal per person per day (Porkka et al., 2013). While critics highlight the risks and costs involved with an isolationist version of 'self-sufficiency', Clapp (2017) calls for a more nuanced understanding that places food self-sufficiency policies along a continuum, rather than as an extreme policy of autarky. Under certain conditions (e.g., large population size, plenty natural resources), countries can enhance food security by decreasing their reliance on imports and by scaling-up domestic food production. Seen in this way, the pursuit of self-sufficiency can go hand in hand with attaining food security.

2.2. Forms of malnutrition

To some, the concept of 'nutrition security' goes beyond the notion of 'food security' because it not only focuses on caloric intake but *also* encompasses several other diet-related aspects (Ingram, 2020). Recently, concerns have been growing over different types of malnutrition, but the link between international trade and nutrition has not yet been thoroughly examined, and the studies that have

[4] This is also evident from the Declaration of Nyéléni (2007), which is signed by many non-governmental organisations (NGO's) that aim to strengthen a global movement of food sovereignty.

addressed it provide us with mixed results. In this paper, we broadly distinguish between three forms of malnutrition: undernutrition, overnutrition, and micronutrient-related malnutrition. It is important to keep in mind, however, that 'minimum' nutritional requirements are not universally applicable as they "have an arbitrariness that goes well beyond variations between groups and regions" (Sen, 1982, p. 12). According to Sen (1982), minimum nutritional requirements are, for instance, strongly dependent on physical features, climatic conditions, and work habits.

First, *undernutrition* simply means that the intake of food is less than a person's needs, which causes several issues such as wasting (low weight-for-height), stunting (low height-for-age), underweight (low weight-for-age), and starvation leading to death. There has been a great deal of discussion about whether undernutrition is resulting from a lack of food supply, or whether it is merely the (unequal) distribution of food that creates these deficiencies (Myers et al., 2017). It has often been pointed out that the world already produces more than enough food to feed everyone, and still there is no indication that hunger is being – or will be – systematically eliminated (Holt-Giménez et al., 2012; Latham, 2021). The question whether agricultural trade (liberalization) can alleviate or exacerbate problems of undernutrition, is a topic of scholarly debate which we will return to in the next section.

Second, *overnutrition* arises from excessive intake of nutrients, leading to accumulation of body fat that impairs health. This is a growing problem in the world and currently affects over two billion people in the form of overweight and obesity (Clapp, 2020). An unhealthy diet that could give rise to overnutrition typically contains excessive amounts of sugars, fats, and salt and is found commonly in foods that are highly processed (Moss, 2013). Because industrially produced foods tend to be cheap relative to healthy, non-processed foods such as fruits and vegetables, people with low incomes face a higher risk of overnutrition (McLaren, 2007, Elmes, 2016). In addition, Cassels (2006) shows that alarming rates of obesity on Pacific islands can be attributed to the wider availability of nutrient-poor, energy-dense foodstuffs, and how changes in dietary preferences can be driven by foreign influences and food trade.

Third, *micronutrient-related malnutrition* refers to micronutrient deficiencies, such as a lack of important vitamins and minerals, as well as an excessive intake of these micronutrients. Since micronutrients enable the body to produce enzymes, hormones and other substances that are essential for proper growth and development, inadequate availability and intake can cause severe health issues, especially for children and pregnant women (WHO, 2024). There is a growing body of work that explores the causes and consequences of 'hidden hunger', as it is sometimes called, but few studies

so far have addressed the role of international trade in the context of micronutrient-related malnutrition (Popkin, 2004; Gillespie and van den Bold, 2017; Geyik et al., 2021).

Altogether, one or more of these forms of malnutrition affect a significant proportion of the world's population. As the food system has become increasingly globalized, it is important to consider how international trade affects this 'triple burden of malnutrition'.

3. Perspectives on the Role of Trade

The relationship between international trade, food security and nutrition is characterized by conflicting views (Montalbano, 2011; Burnett & Murphy, 2014), which relates to all aspects of food and nutrition security – availability, access, use, stability – as well as the various pathways in which trade can affect them (Hawkes 2015). This section discusses the different perspectives on how trade in food and agricultural liberalization can affect nourishment and human well-being.

3.1 A mitigating or aggravating factor?

While many scholars claim that an open trading system contributes to global food security by making the system more efficient and responsive to shocks (Rutten et al. 2013; Matthews 2014), others stress that a reliance on global food markets gives rise to negative externalities that increase the vulnerability of importing countries (Headey 2011; Puma et al. 2015; Distefano et al. 2018; Burkholz and Schweitzer 2019; d'Amour and Anderson 2020).

One strand of research stresses the main benefits of trade which is, following Ricardian principles, that it allows countries and regions to specialize according to their own comparative advantage, leading to a more efficient allocation of resources. In the case of agricultural production, this means that countries can decouple food consumption from local production and from the availability of sufficient natural resources such as land and water (Martin, 2017). The rapid expansion of agricultural production (i.e., the 'green revolution') accompanied with trade liberalization, made it possible to sustain high-level population growth, also in countries with little arable land (Soby, 2013). According to Anderson (2016), international trade, therefore, is crucial to ensure global food security now, and in the future. "If global warming and extreme-weather events are to become more damaging to food production, then there is all the more reason to be open to international food markets and allow trade to buffer seasonal fluctuations in domestic production. The more countries to do, the less volatile will be international food prices" (Anderson, 2016, p. 16). Dorosh (2001) also underscores

that trade liberalization offers potential benefits for national food security, because it can enable countries to increase food imports in response to domestic production shortfalls.

In contrast, other scholars highlight that trade liberalization has increased the fragilities of countries and individuals in terms of food security. For one, authors have argued that liberal trade policies are harmful to poor rural communities and causes hunger and starvation, because they cannot afford as much food as before (Madeley, 2000; Gonzalez, 2004; Rosset, 2009). In addition, it has been claimed that the merits of trade liberalization may have been overestimated, particularly for low-income countries with a comparative disadvantage in agricultural production (Bouët et al., 2005; Ruddle, 2008; Pyakuryal et al, 2010). Moreover, studies have come to focus on the systemic fragilities associated with the world food economy and have exposed several (potential) adverse effects of trade on food security, such as countries' increased vulnerability to exchange rate volatility, financial speculation, and price shocks (Puma et al., 2015; Sartori and Schiavo, 2015; Davis et al., 2016; Distefano et al., 2018).

Regarding effects of global food prices, Swinnen and Squicciarini (2012) focus on the mixed messages sent out by international organizations: "the arguments put forward today, that high food prices generally hurt the poor, are in contrast with those put forward a few years ago, that low food prices were hurting the poor" (p. 405). Instead, they argue against overly simplistic interpretations and, rather, call upon scholars and policymakers to exercise more precision (distinguishing, for instance, between consumers and farmers) and caution when discussing the relationship between trade liberalization, price effects, and food security.

3.2 The effects on dietary diversity

Trade does not have unequivocal effects on malnutrition either. On the one hand, Martin and Laborde (2018) emphasize that "beyond improving food availability and access, international trade can improve nutrition by allowing better access to a diversified food basket." Indeed, Krivonos and Kuhn (2019) find that trade barriers reduce the variety of products available in Eastern Europe and Central Asia, including fruits and vegetables. Because trade induces changes in prices, and thus in production and incomes, it is found to have a positive effect on dietary diversity. The effects are even stronger for fruit and vegetable diversity.

However, while trade can diversify diets and make healthy foods more accessible, it can also lead to the overconsumption of processed foods and the displacement of higher-quality local produce by cheaper imports (Hawkes, 2015). Blouin et al. (2009) suggest that trade liberalization has increased

the availability of nutrient-poor, unhealthy foods in developing countries. Moreover, trade openness has been linked to a greater availability of oils and fats, correlating with increased obesity in Asian countries (An et al., 2019), Pacific islands (Snowdon and Thow, 2013; Ravuvu et al., 2021), and Sub-Saharan Africa (Boysen et al., 2019). Thow et al. (2011) focus on the 'nutrition transition' in Central America, where trade liberalization has led to higher obesity and chronic disease rates, illustrating the dual nature of trade's impact on diet costs and health. Law's (2019) study on early 1990s Indian trade liberalization shows that rural diets shifted from traditional staples to more animal products, improving micronutrient intake but also increasing obesity and diet-related illnesses. These shifts are influenced by income and food prices, but local food preferences also play a crucial role. Atkin (2013) proposes a theoretical framework linking tastes and trade, showing that as long as tastes are shaped by local conditions, the nutritional gains from trade liberalization may be smaller than expected. This is because preferred local varieties, in which a country has a comparative advantage, could become more expensive relative to less preferred imported foods due to habit formation. Thus, trade's negative impact is limited by consumer preferences, provided that ultra-processed foods high in sugar, saturated fats, and salt are not prevalent in the local diet.

A recent study by Masters et al. (2022) examine the cost and affordability of a healthy diet (CoAHD) in Africa and other regions. The study focuses on identifying the most economical food baskets that fulfil minimal nutritional requirements, indicating that the findings mostly relate to low-income households, who are the most vulnerable subset of the population. The report concludes that trade barriers contribute minimally to the final cost paid by consumers, implying that trade liberalization will have a negligible impact on the CoAHD. Additionally, the authors note that nearly 50 percent of low-cost products are domestically sourced, further constraining the potential for trade openness to significantly influence prices.

What is more, Springmann et al. (2023) show that the effects of international trade – i.e., whether the contribution is positive or negative – depend on the types of food traded. They estimate that trade in fruits, vegetables, legumes, and nuts improved dietary conditions and leads to a decrease in mortality from non-communicable diseases of ~1.4 million deaths globally. Conversely, imports of red meat have a negative effect on human health and is associated with a worldwide increase of ~150,000 deaths. Cuevas García-Dorado et al. (2019) review quantitative evidence on globalization's effects on nutrition, confirming mixed results. They did not find a clear link between trade liberalization and noncommunicable diseases but did find evidence that openness improves dietary diversity and reduces malnutrition. However, the impacts of trade vary significantly by country and

across different population strata. While trade can improve access to diverse and nutritious foods, it can also lead to increased availability of unhealthy processed foods and higher rates of diet-related diseases.

Traverso and Schiavo (2020) focus particularly on low-income countries, and they find that those countries can profit from international trade by exporting high-price crops while importing cheaper food products. Overall, they show that international trade has a positive impact on the total amount of food available in low-income countries. Both for macronutrients (such as carbohydrates and proteins) and for micronutrients (such as vitamins and minerals), low-income countries register a net inflow, which suggests that trade can enhance food security in terms of access and availability. Traverso and Schiavo (2020), therefore, conclude that international food trade can lead to an increase in low-income countries' net welfare (by capitalizing on food price differentials) without lessening the amount of nutrients available domestically.

3.3 Export restrictions in times of crisis

The WTO Agreement on Agriculture (AoA) devotes ample attention to food security. In fact, food security is taken into consideration throughout the AoA (Alabrese 2018; Margulis 2017), and in the Preamble, food security is described as a non-trade concern together with environmental issues (Trapè 2014; Grossman 2003). The AoA includes measures such as holding of food stocks for security purposes and the provision of food aid to the population in need (Konandreas and Greenfield 1996). While exports should not be restricted or prohibited, this rule finds an exception under art. 12 of the AoA in the case of critical shortages of foodstuffs. Art. 12 requires countries to give "due consideration" to the effects of export restrictions on the food security of trade partners. However, scholars have noted that the actual implementation raises several issues since "due consideration" falls short of a proper impact assessment with potential serious negative effects on the food security of importing countries (Haberli 2010; Smith 2012). Moreover, in a tightly interconnected world, it is often difficult to properly assess direct and indirect effects of trade restrictions. In fact, export bans are a common tool used by several countries to face disruptions in food supplies (Abbott 2012; Giordani et al. 2016; Espitia et al. 2020).

Many authors claim that export restrictions have unintended consequences (Grassia et al. 2021) and can exacerbate shortages and price spikes (Timmer, 2008; Abbott, 2012; Giordani et al. 2016). Headey (2011) finds that during the 2008 food crisis, nearly all of the surge in rice prices could

be explained by a combination of increased demand and export restrictions imposed by India and Vietnam. During the COVID-19 pandemic in 2020, countries also imposed export restrictions on food products, which scholars warned could destabilize world markets (Laborde et al., 2020). "A key problem with export restrictions is that they can create the upward spiral in world prices that they are intended to prevent" (Laborde et al., 2020, p. 3). Since most of these export restrictions were were removed relatively quickly, they did not play a key role in the increases in international food prices as was the case during the 2008 crisis (Kowalska et al., 2022).

Under extreme conditions, such as famines, a lack of export restrictions and a strict adherence to free trade principles can be problematic as well. Sen (1982) famously reported that in many cases (e.g., in Bangladesh in 1974), food was being exported from the famine-stricken while large numbers of people died of starvation, which he explained as follows: "Market demands are not reflections of biological needs or psychological desires, but choices based on exchange entitlement relations. If one doesn't have much to exchange, one can't demand very much, and may thus lose out in competition with others whose needs may be a good deal less acute" (p. 161). Overall, the effects of trade policies in times of crises, and the use of export restrictions in particular, depend on contextual factors such as timing and the severity of the food crisis.

4. A Network Approach

Given the interconnectedness of countries and issues in the global food system, the use of complex network analysis has become increasingly popular. This approach provides researchers with tools to analyse both local and systemic fragilities, the occurrence of cascade effects, and to study the role played by the position of each country within the international trade network, above and beyond country characteristics such as income, openness, or the availability of reserves. This section highlights the main properties of this approach as well as its findings.

4.1 Shock transmission and resilience

An emerging literature focuses of the stability of food supply and questions about the role of trade in mitigating the risks associated with idiosyncratic shocks to domestic production (Dorosh et al. 2009; Dorosh and Rashid 2013; Tai et al. 2014; Grassia et al. 2022), or rather spreading exogenous shocks, thus increasing the vulnerability of importing countries (Headey 2011; Puma et al. 2015; Distefano et al. 2018; Burkholz & Schweitzer 2019; d'Amour and Anderson 2020), especially if it induces

reliance on a small number of sources (Kummu et al. 2020). Within this literature, many scholars use complex network analysis to shed light on the interdependence between countries arising from their integration in the global food system.

The literature finds that although globalization has not undermined the overall stability of the food system (Fair et al. 2017), in some regions of the world importing countries have experienced a higher volatility of supply (Puma et al., 2015; Davis et al., 2016; Distefano et al., 2018, Grassia et al. 2022). More specifically, the spreading dynamics crucially depend on the topology of the network, in particular the presence of densely connected communities (Torreggiani et al. 2018). The possibility that sudden decrease in agricultural production can lead to cascades propagating through the trade network has been addressed both looking at a single source of the shock (Heslin et al. 2020 for the US) or across several countries (Burkholz and Schweitzer 2019; Grassia et al. 2022).

In addition, scholars have used network analysis to study the water 'embodied' in food products, and how this water is 'virtually' traded between countries (Sartori and Schiavo, 2015; Vallino et al., 2021). Through this mechanism, international trade may enable countries to better cope with water scarcity which directly affects food and nutrition security. Sartori and Schiavo (2015) examine how countries' participation in global agricultural trade affects their vulnerability to external shocks, focusing in particular on the effects on virtual water trade. They find that the number of trade connections and the volume of water contained in traded goods has almost doubled between 1986 and 2010 and, most importantly, that increased globalization has not led to more systemic instability. Quite the contrary, Sartori and Schiavo (2015, p. 121) conclude that "the benefits from the dissipation of shocks through the network outweigh the potential costs of shock propagation and magnification."

4.2 Nutritional content and major crops

Silvestrini et al. (2024) conduct a network analysis to assess how food trade plays a role in the global distribution of essential nutrients (protein, calcium, iron, and vitamins A and B12). Their aim is to find out whether higher participation in nutrient trade networks is associated with more (or less) favourable health outcomes during childhood and adulthood in the short and long term. They demonstrate that trade in all nutrients has increased rapidly since 1986, but this increase has been largely confined to high-income countries and upper-middle-income countries. For lower-middle-income counties and low-income countries, however, their results point in a different direction. Due to the low and (proportionally to their size) decreasing involvement of these countries in the global

trading network, Silvestrini et al. (2024) find that the positive influence of trade on nutrient deficiency rates in poorer populations is very limited, which are the places where malnutrition is most prevalent (Geyik et al., 2021).

Wang et al. (2023) also analyse the food-based availability of a broad range of macronutrients (calories and protein) and micronutrients (vitamin C, vitamin A, vitamin B3, vitamin B6, vitamin B12, iron, zinc, calcium and magnesium) at country, regional and global levels. At the aggregated level, they note that the availability of macronutrients per person was adequate but, in line with Silvestrini et al. (2024), they find enormous disparities across countries. Relatively poor countries in Sub-Saharan Africa and in Southeast and Central Asia still showed moderate or mild deficits for one or both macronutrients. When it comes to micronutrients, Wang et al. (2023) reveal even more alarming deficits: a majority of the countries were in deficit for all nine micronutrients. Again, low-income countries are worst off because the micronutrients with the highest deficits (vitamin A, calcium and vitamin B12) are primarily contained in relatively expensive animal-source foods or dietary supplements. Wood et al. (2018) also show that deficits of micronutrients – rather than macronutrients – are most severe and they argue that international trade can be mechanism which may enable poorer countries to meet their nutritional needs.

Another set of papers focuses on the main staples – wheat, corn, and rice – that account for the largest shares of global nutritional intake. Considering wheat, the most important source of carbohydrate in most countries, Fair et al. (2017) explore the impact of shocks on the structure of the global trading network and its response to subsequent shocks. Within their model, they examine the effects of different shocks – in terms of severity and duration – and they also simulated the impacts of export bans on the spread of repeated shocks. Fair et al. (2017) show that, overall, there has been a transition towards a more stable network configuration where countries maintain trade links with a diverse group of partners, which suggests that the trading network is becoming less vulnerable to negative (supply) shocks. As a disclaimer, however, Fair et al. (2017, p. 11) note that future shocks may still have a significant impact on the wheat trading network: “Extreme climate events, such as floods, droughts, and heat stress, are predicted to increase in frequency, both globally and in regions of Europe where most of the world’s wheat is produced, over the remainder of the 21st century. Thus, strategies for lessening the impact of shocks on the network will become increasingly crucial to global food security and are an important area for future research.”

In terms of production volume, corn (or maize) is the leading cereal in the world and demand is increasing because it can be used for multiple purposes. In Europe and North America, the crop is

primarily used to feed livestock whereas in other areas – such as Sub-Saharan Africa, Asia and Latin America – it is (also) an important human food crop, contributing over 20 percent of food calories (Shiferaw et al., 2011). Erenstein et al. (2022) provide an overview of international corn production, consumption and trade patterns, and they highlight the vulnerabilities of the global food system. Since production and exports are concentrated in the U.S., a negative shock in the Corn Belt (e.g., due to extreme weather) can lead to a surge in global maize prices which, in turn, can have strong repercussions for import-dependent countries (primarily in East Asia). Moreover, Erenstein et al. (2022) underline that corn – in the form of livestock feed – also provides a pathway towards protein-rich, animal-sourced food products and, hence, can help to reduce undernutrition as well as micronutrient-related malnutrition.

Lastly, rice is the primary calorie source for millions of people in Asia and it is also emerging as an important staple in Africa and Latin America (Li et al., 2024). In their in-depth network analysis, Li et al. (2024) reveal that the rice trade network underwent a significant expansion over the past thirty years, with a fourfold increase in trade connections between 1986 and 2021. In addition, they show that the network has become more cohesive and resilient as a whole, while the power distribution (that is based on the position in the network) has become more unequal. This means that some countries are now more dependent on rice imports from a few suppliers and that they are vulnerable to price increases. This is problematic in terms of food security because rice tends to experience stronger supply and price fluctuations than other major crops such as wheat and corn (Li et a., 2024).

5. A Research Agenda

We have given an account of the existing scholarship on the link between international trade and food and nutrition security. We have described several concepts, theories, methodologies, and results that offer various and conflicting perspectives on the role of trade (policy) and which, altogether, highlight the complexity of the global food system. While we have strived for relative comprehensiveness, we have focused primarily on recent insights from the literature, which means that we have deliberately not expanded on the historical roots and developments that have shaped the current food trade network (as well as the academic debate). In section, we sketch a number of possible, future avenues for further research.

First, we note that the impact of trade on micronutrient-related malnutrition has attracted comparatively little scholarly attention. Given that this form of malnutrition affects around two billion

people and because inadequate intake of micronutrients can lead to serious and long-lasting health issues (Beal et al., 2017), it would be desirable if more scholars try to systematically assess the effects of international trade flows on micronutrient-related malnutrition across different countries and regions. More generally, in comparison with the huge and detailed literature on 'food security', the concept of 'nutrition security' remains underdeveloped, and further research could be done to move towards a (more) widely accepted meaning and usage of this term that is (potentially) more appropriate when analysing the problems in today's global food system.

Second, another promising avenue is to tease out the effects of climate-induced variabilities and weather extremes for the production, consumption and trade of specific commodities. As climate change is expected to exacerbate the occurrence and impacts of several biotic stresses (Erenstein et al., 2016), it is important to identify the risks for each crop and, in turn, to explore different strategies to secure food and nutrition security in areas that are (indirectly) affected by production shortfalls. As we have seen in this literature review, international trade can be mechanism through which countries can maintain access to nutritious food while, at the same time, a dependence on food imports (e.g., processed foodstuffs) can also have strong negative externalities. Future research could shed light on how policymakers can strike a balance between these various interests.

Finally, this paper has shown that network analysis can offer a fruitful approach for the study of trade, food security, and nutrition security. In line with Elliott and Golub (2022), we call for better measurements as a stepping stone for understanding network fragility. Further efforts are needed to design simple and effective tools to assess the vulnerability of countries to exogenous disturbances. A desirable next step is to build dynamic models of multi-annual, commodity-specific networks in order to gain insight into possible futures of global agri-food trade networks (Sartori and Schiavo, 2015; Fair et al., 2017). Once countries' vulnerabilities to specific shocks and potential future scenarios are known, it will be possible to create a 'early warning system' that may help political leaders and professionals to respond more effectively to food emergencies and to prepare for difficult times ahead.

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