European Review of Agricultural Economics, Vol **00** (**0**) (2026) pp. 1–28
https://doi.org/10.1093/erae/jbag018

Advance Access Publication 11 September 2026

Trade diversification and food price volatility

Bernhard Dalheimer *

Department of Agricultural Economics, Purdue University, United States

Received 10 May 2025; Final version accepted 1 July 2026

Abstract

Recent shortages and price volatility have exposed vulnerabilities in international agri-food value chains. This paper develops a new framework for measuring trade diversification based on Hill numbers, which capture both the extensive and intensive margin of trade connections. Using HS6-level bilateral data for 188 countries from 2000 to 2022, I first document global patterns of diversification and concentration across agri-food sectors. The descriptive evidence shows that most countries trade with many partners in principle, yet effectively rely on only a few, especially for grains and oilseeds. I then estimate the effect of import and export diversification on within-year food price volatility using a shift–share instrumental-variable design that exploits exogenous foreign sector-level shocks weighted by lagged bilateral trade exposure. The empirical results show that more balanced and diversified import portfolios are strongly associated with lower food price volatility, whereas export diversification plays a more limited role. Policies encouraging diversification can reduce food price volatility but involve trade-offs between efficiency from international specialization and resilience of the input–output network.

Keywords: international agricultural trade; diversification; food price volatility; resilience; global agrifood value chains

JEL classification: Q17, F14, E32

1. Introduction

Recent volatility in agricultural prices, along with shortages in some regions, has highlighted the lack of resilience in global agri food systems. While international trade plays a key role in balancing food supply and demand across countries, many agri-food imports and exports remain heavily concentrated among a limited number of trading partners. The lack of diversification in international food sourcing amplifies supply shocks, trade policy changes, and

*Corresponding author: E-mail: bdalheim@purdue.edu

geopolitical disruptions which ripple through food supply chains and may reduce resilience of food supply around the globe.

This paper investigates how the lack of diversification of global agri-food imports and exports affects food price volatility and by extension compromises food systems resilience. Trade theory predicts efficiency gains from specialization and international trade, yet it also predicts geographic concentration of production which can imply vulnerabilities through supply chains to environmental or policy shocks that occur in foreign countries. This duality implies that the degree of diversification (concentration) of international trade on both the import and export side determines how robust agri-food systems are to domestic and international shocks.

I propose a framework to measure global agri-food trade diversification and estimate its effect on food price volatility. Using BACI data (Gaulier and Zignago, 2010) at the six-digit product code level, I construct Hill numbers (Hill, 1973) or number equivalents, to construct measures which balance *uniformity* (or evenness, measuring the intensive margin), and *richness* (or number of links, measuring the extensive margin) of international agri-food trade. First, I provide a descriptive overview of concentration and diversification of agri-food trade. Second I use a shift–share instrumental variable (SSIV) design to estimate the effect of import and export diversification on the coefficient of variation (CV) of monthly national food prices in a country-level panel of 188 countries during 2000–2022.

Four key findings emerge from this work. First, international food trade is not diversified. Second, agri-food trade is not diversified not because countries lack potential trading connections, but because trade volumes are unevenly distributed among the partners they do have. Third, trade concentration is heterogeneous. It is more pronounced for lower-income countries and primary commodities than for higher-income countries and processed foods, and has been increasing since 2016 after a sustained period of global diversification. Fourth, food price volatility is strongly associated with trade concentration, more strongly so with the evenness of trade shares than with the number of trade partners, and more on the import than on the export side.

With regards to food policy, these findings emphasize the role of balanced import portfolios in improving market-related food systems resilience. Compared with self-sufficiency policies, which add at best one more supply country to the input–output network, adding more reliable sources and destination markets is a more promising approach than focusing on domestic activity alone. However, as both higher efficiency and specialization are key outcomes of international agri-food trade, diversification policies will trade-off losing gains from trade against more resilient food markets at home.

This study contributes to the literature in three ways. First, this paper proposes Hill numbers as a measure of international import and export concentration (diversification). While the literature has used the Herfindahl–Hirschman Index (HHI) to measure concentration, the Hill numbers framework reconciles several concentration measures and distinguishes them by their relative weighting between intensive and extensive margins, allowing more nuanced diversification analyses. Equipped with this new measure, this paper contributes to a growing literature examining the resilience of global food systems through the lens of trade structure. Earlier work documents how growing trade integration has improved supply diversity but also increased systemic exposure to disruption (Kummu *et al.*, 2020; Arita *et al.*, 2022; Dalheimer and Bellemare, 2026). Network-based analyses have shown that concentrated trade relationships can amplify the propagation of shocks across countries (Karakoc and Konar, 2021; Wang and Liu, 2023).

Second, the literature on agri-food trade policy and market stability has focused on food self-sufficiency and trade dependence (e.g. Clapp, 2017; Puma, 2019; Kiloes *et al.*, 2024; Haqiqi and Hertel, 2026), policy co-ordination (e.g. Gouel, 2016), regulation and standards (e.g. Bemelmans *et al.*, 2023; Fiankor *et al.*, 2024), trade and price support policies (Josling and Tangermann, 1999; Jayne *et al.*, 2006; Anderson *et al.*, 2013; Rude and An, 2015; Pieters and Swinnen, 2016; Gaigné and Gouel, 2022; Raimondi *et al.*, 2023; Nes *et al.*, 2025b; Schaefer and Wolf, 2025; Hoffmann *et al.*, 2026; Martin *et al.*, 2026), storage policies (Gouel, 2014; Gouel and Wright, 2026; Dalheimer *et al.*, 2026b) and sanctions (Fedoseeva and Herrmann, 2019; Larch *et al.*, 2024; Tian 2026), while the relationship between trade diversification and market stability has been largely overlooked.

Trade theory suggests that, while trade induces welfare gains through specialization and efficiency, it also introduces vulnerabilities. For instance, Turnovsky (1974) and Batra and Russell (1974) demonstrate that trade can increase supply uncertainty, to the extent that welfare could even be lower than under autarky for countries where consumers are particularly risk-averse. Similarly, Feder *et al.* (1977) show that the increased uncertainty of prices incentivizes countries to reduce trade dependence in favor of optimizing domestic storage–production–consumption relationships. Newbery and Stiglitz (1984) argue that global price shocks can lead to allocative responses that reduce welfare, even in open economies. Some empirical evidence supports these theoretical insights, with studies showing that trade dependence can negatively affect business performance and exacerbate vulnerabilities in the domestic market (e.g. Appelbaum and Kohli, 1997, 1998; Gouel, 2012; Novy and Taylor, 2020; Allen and Atkin, 2022), and that policy is more likely to be trade restrictive when faced with random shocks (e.g. Amodio *et al.*, 2024; Nes *et al.*, 2025a). Conversely, reducing trade-related uncertainty can yield stronger welfare gains than simply lowering trade barriers (Limão and Maggi, 2015; Gervais, 2021). Yet, several papers on the export side show that firms tend to concentrate their business activities into few international trade relationships (Arkolakis and Muendler, 2013; Fiankor, 2023; Beck *et al.*, 2024; Villoria, 2025) suggesting that international shocks will be amplified rather than buffered through trade. This paper builds on this literature by providing empirical evidence on how diversification within trade networks—rather than reliance or self-sufficiency per se—affects the stability of agri-food sectors.

Third, the literature on supply chain concentration in food and agriculture has primarily focused on domestic markets, particularly in US food systems, and on the firm level in international contexts. Richards *et al.* (2025), Saitone *et al.* (2024), Hadachek *et al.* (2024), Stevens and Teal (2024), Wahdat and Lusk (2023) and Ma and Lusk (2021) analyse the impact of concentration in domestic food supply chains, emphasizing how reliance on a few suppliers compromises resilience. International firm-level evidence further highlights the importance of diversification for managing policy shocks and mitigating risks (e.g. Beck *et al.*, 2024; Fiankor *et al.*, 2024). Dalheimer and Bellemare (2026) show that global agri-food value chain integration may increase price volatility and suggest that concentration trade relations could be the transmission channel while Clapp (2023) offers qualitative insights on multilevel concentration in global food supply industries. This paper offers a macroeconomic country-level perspective by examining how concentration and diversification in international trade flows influence food price volatility at the country level.

The remainder of this paper proceeds as follows. Section 2 provides descriptive statistics and figures on the diversification of international food trade. Section 3 develops the empirical model. Section 4 presents the effect of import and export concentration on food price volatility. Section 5 discusses the findings with regards to food policy, and Section 6 concludes the paper.

2. Diversification measures and data

Resilience of agri-food systems has been defined in several ways, focusing on various dimensions. While one strain of the literature emphasizes social and environmental vulnerabilities in food systems' resilience concepts (Tendall *et al.*, 2015; e.g. Seekell *et al.*, 2017), this study focuses on the market and supply-chain aspects of resilience. Specifically, the availability and affordability of food during crises. Since food production is climate and region-specific and consumers often live far from production sites, trade and global value chains are key to food availability and accessibility. With globalized food production, shocks in one part of the world have implications in others.

Drawing on portfolio theory, diversified sourcing spreads random risk and reduces a country's exposure to idiosyncratic shocks. Risks can be minimized by maximizing the number of assets and minimizing correlated. This logic has been applied in recent trade and network stability models (Gervais, 2018; Elliott *et al.*, 2022; Baqaee and Farhi, 2024), which show that shocks propagate more intensely in centralized networks. In this context, import concentration can increase the exposure to supply disruptions or policy shocks in partner countries, while diversified sourcing provides more resilience. Vice versa, reliance on a small number of buyers may increase a country's exposure to external demand, supply or policy shocks.

2.1 Hill numbers

Information theory, biology, physics and economics use diversity measures to describe system resilience. To quantify diversification, various indicators offering unique insights into the system's composition have been developed. Among these, the use of numbers equivalent, or Hill numbers[1] has emerged as a robust approach to interpret diversity measures as the effective number of elements, thereby providing an intuitive and comparable framework (Adelman, 1969; Patil and Taillie, 1982; Jost, 2006). Traditional concentration measures in economics, such as the Herfindahl index, can be transformed into numbers equivalents to represent the effective number of equally important categories. This transformation aids in addressing the skewed nature of raw indices, which may obscure the underlying dynamics of concentration and dispersion, as diversity is a multifaceted construct encompassing richness (number of links), evenness (distribution of shares across links) and disparity (difference between links) (Jost, 2006).

Hill numbers aim at capturing the effective number of categories in a system, and are derived from the concept of the generalized entropy index and incorporate a sensitivity parameter (q) that adjusts the emphasis on evenness of categories:

$$D_q = \left(\sum_{i=1}^{R} s_i^q \right)^{\frac{1}{1-q}}, \tag{1}$$

where, R is the total number of categories (e.g., links or suppliers), s_i represents the share of the ith category in the system and q is the sensitivity parameter. When $q = 0$, D_0 measures richness (the total number of categories), providing a measure that is only sensitive to the total number of categories. When $q = 1$, D_1 is undefined but its limit $\lim\limits_{q \to 1} {}^{q}D = \exp\left(-\sum_{i=1}^{R} s_i \ln s_i\right)$, with $\ln s_i \times s_i = 0$ for $p_i = 0$, is the exponential of the Shannon entropy and measures the effective number of categories, emphasizing evenness and richness to the same extent. When $q = 2$, D_2 corresponds to the Herfindahl index, giving higher weight to dominant categories. This measure has been widely used to measure industry concentration.

Hill numbers can help assess how diversification within agri-food trade varies depending on the weighting of category dominance. For example, D_0 provides a basic count of input suppliers or output markets but does not account for disparities in importance of each of the suppliers or markets. D_1 captures the balance across categories, considering the evenness of reliance on different supply sources or markets and describe effective number of links. The measure translates the actual number of input suppliers (output markets) to the hypothetical number of equally important input suppliers (output markets). D_2 gives more weight to the degree of concentration compared with the

1 The term "Hill numbers" originates from the work of ecologist Mark Hill, who introduced this framework in 1973 to unify various diversity indices used in ecological studies (Hill, 1973).

number of categories. Using this framework, diversification measures can be derived by varying q.

2.2 Diversification measures

Number of trade links. The total number of trade links (D_0), or how many countries one country trades with, is a straightforward measure of richness, representing the variety of connections of a global agri-food system. A high number of trade links suggests a wide array of source or destination countries for commodities. However, this metric does not account for the distribution of trade volumes among links.

Effective number of trade links. The effective number of links represents the number of equally significant categories that would produce the observed level of diversity. Using the Hill numbers framework, the effective number at $q = 1$ may be expressed as its limit:

$$D_1 = -\sum_{i=1}^{R} s_i \ln s_i. \tag{2}$$

This transformation expresses diversity in terms of an equivalent count of equally important trade links or categories.

Normalized effective number of trade links. To facilitate comparisons across systems with varying sizes or scales, the normalized effective number adjusts the effective number relative to the maximum possible diversity for the given system size. For a system with R categories, the normalized effective number is:

$$\text{Normalized Effective Number} = \frac{D_1}{R}. \tag{3}$$

This measure contextualizes diversity within the system's potential range and describes the extent to which diversification is maximized. A low normalized effective number indicates unrealized diversification potential, even if the absolute effective number appears large.

HHI. The HHI, also known as the Simpson Index in diversity studies, measures the concentration of trade across categories. It is calculated as

$$\text{HHI} = \sum_{i=1}^{R} s_i^2, \tag{4}$$

where s_i is the proportion of trade attributed to the ith link. The HHI ranges from 0 (perfectly uniform distribution) to 1 (complete concentration in a single category). As a concentration metric, the HHI measures vulnerabilities arising from over-reliance on dominant partners or commodities. Compared with the effective number of links, the HHI gives more weight to dominant trade connections. In the descriptive analysis of Section 2, following convention in the industrial-organization literature, I report the HHI on a 0–10,000 scale (i.e., based on percentage shares, with values above 1,500 indicating market concentration). In the econometric analysis of Section 3, I use the equivalent 0–1 share-based scale. Both constructions represent the same statistic and differ only by a factor of 10,000.

Gini coefficient. Another common measure, complementary to numbers-equivalents indicators, yet widely used is the Gini coefficient. It measures inequality within the distribution of trade shares across categories:

$$G = \frac{\sum_{i=1}^{R}\sum_{j=1}^{R}|s_i - s_j|}{2R\sum_{i=1}^{R}s_i}. \tag{5}$$

The Gini coefficient ranges from 0 (perfect equality) to 1 (maximum inequality). Unlike the HHI, which focuses on concentration, the Gini coefficient captures disparities across the entire distribution, making it particularly valuable for identifying systems with moderate imbalances rather than extreme concentrations.

In summary, these indicators allow to measure concentration of international trade by (i) identifying the breadth of import and export connections of a country, (ii) quantifying concentration and its implications for systemic risks, (iii) contextualizing diversification within the system's maximum potential and (iv) highlighting distributional inequalities that may compromise resilience of food supply.

2.3 Data

I use the HS96 version at the six-digit product level from BACI of CEPII (Gaulier and Zignago, 2010) and define agri-food trade using HS chapters 01–23, which include live animals, meat, dairy, vegetables, fruits, grains, oilseeds and food-related agricultural raw materials. This scope follows common classifications in agricultural trade analysis and is consistent with several other authors (e.g. Gaigné and Gouel, 2022). The dataset contains annual bilateral import and export data of 188 countries from 2000 to 2022.

For the descriptive analysis by sectors, I group commodities of HS chapters 01 through 05 into animal and animal products, 06 through 08 into vegetables and fruits, 09 into coffee, 10 and 11 into cereals, grains and flour, 12 through 15 into oilseeds and products, 17 into sugar, 18 into cocoa and 16 and 19 through 23 into processed foods.

For the empirical analysis, I combine these data with food price data from FAOSTAT monthly food consumer price index (CPI) database.[2] FAO's Food Price Index (FCPI) tracks retail price movements of all food items consumed by households. This includes cereals, meat, dairy, oils, fruits, vegetables and sugar, among others.

While the FCPI is weighted by domestic consumption and the trade data reflect international flows, both datasets cover the same broad set of food staples that shape availability and pricing in domestic markets. Thus, while not identical in structure, the FCPI and trade exposure variables are compatible

2 Data available at https://www.fao.org/faostat/en/#data/CP.

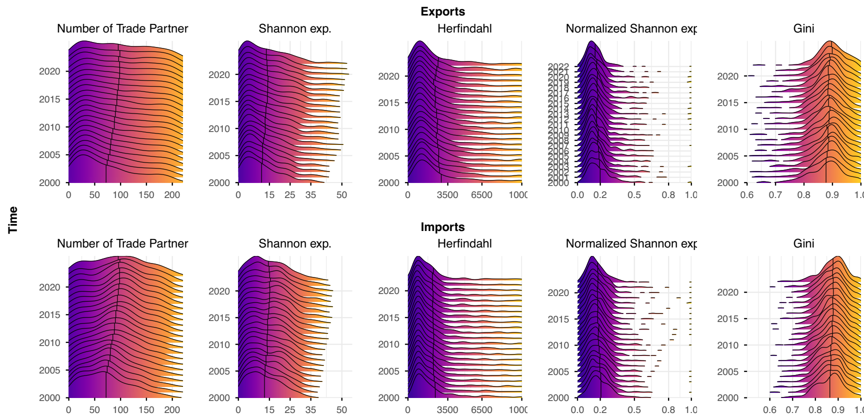

Fig. 1. Cross-country distributions of trade diversification in the food and agriculture sector over time.

Each ridge displays the kernel density of the cross-country distribution for a given year. Solid horizontal ticks (or lines) mark cross-country means The first the average numbers of import or export countries $D_0 = R$, the fourth the Shannon exponential, or effective number of trade partners ($D_1 = -\sum_{i=1}^{R} s_i \ln s_i$.), the third the Herfindahl (or Herfindahl–Hirschman) Index, $D_2 = \sum_{i=1}^{R} s_i^2 \times 10,000$ where values over 1,500 indicate market concentration, the fourth the normalized number of effective trade partners (e^{D_1}/D_0), which ranges from 0 to 1, with lower values indicating skewed distributions, and the fifth the Gini coefficient, where 1 means 1 per cent of countries supply 100 per cent of the good, and 0 means equal contribution from all countries, of agri-food sectors.

for analysing how concentrated sourcing patterns relate to food price volatility at the national level.

2.4 Descriptive results

Before examining the effects of trade diversification on market stability, I describe the compiled measures of diversification using several graphs. In particular, I compile the five indicators for each country's agri-food sector, which represents the aggregate trade value of all agri-food commodities, as well as for the country-product level. Section 1.1 of the Supplementary material lists maps of global distribution of import and export concentration measures and depict the development of diversity measures over time.

Global agri-food trade is not diversified because of a lack of uniformity, not because of a lack of richness. Figures 1 and 2 show the distribution of diversity measures of the entire food and agriculture sectors (Fig. 1) and for individual commodities of the sector (Fig. 2). While the number of export and import partner countries averages at around 70–90, the distribution is skewed to the left. Most countries trade with far fewer partners than the mean suggests. This is further evidenced in the Shannon exponential, HHI and Normalized Shannon exponential. *Effectively*, countries trade with about 15–16 partners, while the majority of national agri-food sectors are connected to only 4–5 partners.

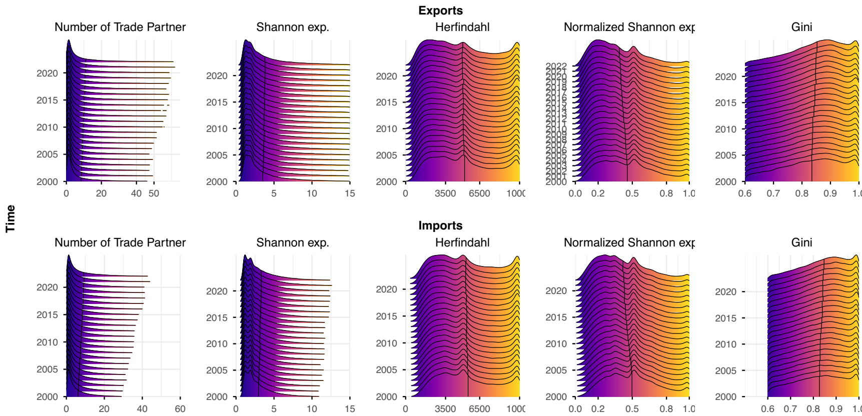

Fig. 2. Cross-commodity distributions of trade diversification in food and agriculture over time. Each ridge displays the kernel density of the *country–commodity* (HS6) distribution for a given year, in contrast to Fig. 1, which aggregates at the country level across all agri-food products. Here, each observation represents one country's export or import pattern in a specific agri-food product at the HS6 level. Solid horizontal ticks (or lines) mark means. The first panel reports the average number of trading partners ($D_0 = R$); the second the Shannon exponential, or effective number of trade partners ($D_1 = e^{-\sum_{i=1}^{R} s_i \ln s_i}$); the third the Herfindahl–Hirschman Index ($D_2 = \sum_{i=1}^{R} s_i^2 \times 10{,}000$), where values above 1,500 indicate market concentration; the fourth the normalized effective number of partners (e^{D_1}/D_0), which ranges from 0 to 1 with lower values indicating skewed partner shares; and the fifth the Gini coefficient, where 1 indicates that one partner supplies all trade and 0 denotes perfect equality across partners.

In terms of the HHI, such agri-food sectors do not necessarily mean that they are concentrated, as the bulk of observation is close to or lower than the 1,500 threshold which would indicate a competitive market. However, this number reflects the weight given to large shares of that distribution, as indicated by the normalized Shannon exponential, which tells us that most agri-food sectors rely on only about 20 per cent of their available trade partners in both imports and exports. The Gini coefficients are also high, averaging at 0.8.

The finding of concentration in agri-food sectors is further illustrated at the more disaggregated *country–commodity* (HS6) level depicted in Fig. 2 rather than at the aggregate agri-food sector level. Each observation represents one country's export or import pattern in a specific HS6 product category. This finer level of analysis reveals that most individual products are traded, for the largest part with only one, two or three countries. The ridgeline distributions show this multimodality across all indices, suggesting the presence of distinct regimes corresponding to one, two, three or a handful of dominant trading partners.

The distribution of diversity metrics show that a small number of countries dominate food trade across countries and thus suggest significant reliance on a few exporters. A case in point is cocoa, which is produced in and exported by about 50 countries. Yet Ghana and Côte d'Ivoire account for over 50 per cent of global trade, with others holding each less than 7 per cent. Similarly, the

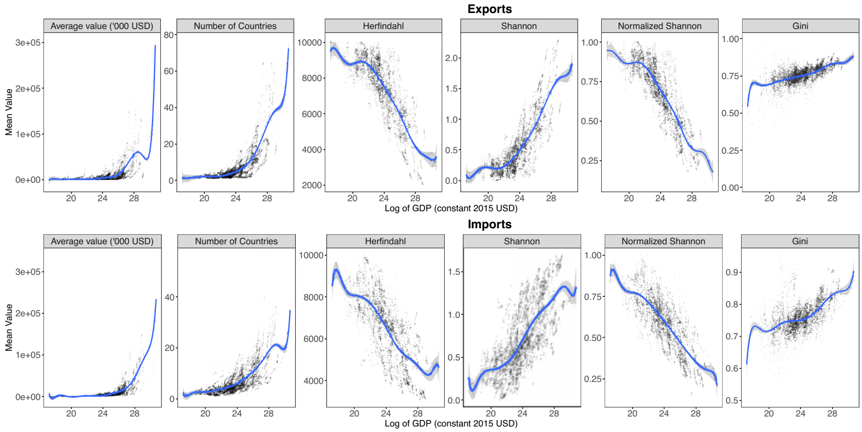

Fig. 3. Number of supply countries, HHI, normalized Shannon entropy and Gini coefficient for global agri-food imports and GDP.
The first column shows average trade values, the second the average numbers of import or export countries, the third the Herfindahl (or Herfindahl–Hirschman) Index, where values over 1,500 indicate market concentration, the fourth the shannon exponential, or effective number of trade partners, the fifth the normalized number of effective trade partners (0–1), with lower values indicating skewed distributions, and he sixth the the Gini coefficient, where 1 means 1 per cent of countries supply 100 per cent of the good, and 0 means equal contribution from all countries, of agri-food products at the HS-6 level.

international trade of sweet potatoes is concentrated as well, with US exports making up 37 per cent of global trade, followed by Vietnam with 12 per cent.

Global country-level agri-food trade concentration has decreased until about 2016 and subsequently increased. Between 2000 and 2016, several diversification metrics have increased. Both in Figs 1 and 2, and more explicitly in Figs 2 and 3 of the Supplementary material, gradually increasing trade partnerships from 80 to almost 100 on the export side, and from about 75–95 on the import side. The HHI values declined, normalized effective numbers rose and even the Gini coefficients were stagnating during this period, signaling developments towards more evenness and reduced concentration. However, post-2016, these trends reversed, where HHI values started increasing again, normalized effective numbers stagnated or declined and Gini coefficients began to rise. Moreover, the distributions of the indicators widened. Few very diversified sectors helped increase the mean pre 2016. In more recent years, these countries continued the trajectory of diversification while the bulk of agri-food sectors exhibit strong reductions in trade diversification. Both the changes in measures as well as their distribution point to a deterioration of resilience in global food systems.

Food trade of lower-income countries is more concentrated than that of higher-income countries. Figure 3 shows the diversity measures in relation to GDP. Lower-income countries face significantly more concentrated trade integration compared to their higher-income counterparts. This is evident

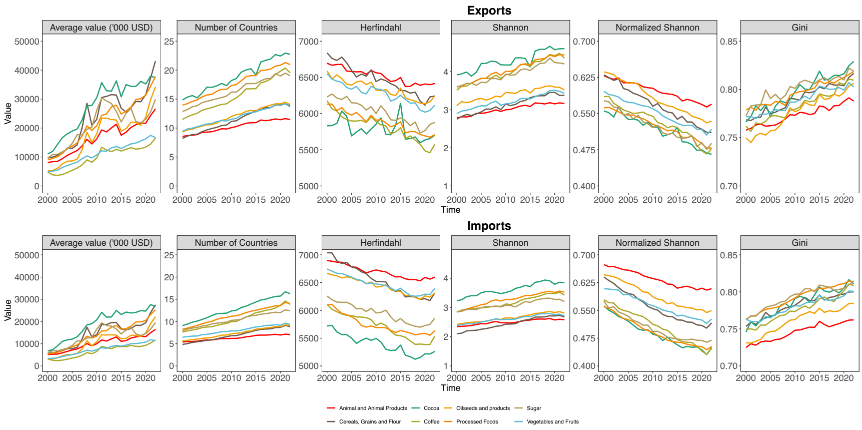

Fig. 4. Number of supply countries, HHI, normalized Shannon entropy and Gini coefficient for global agri-food imports by food groups.
The first column shows average trade values, the second the average numbers of import or export countries, the third the Herfindahl (or Herfindahl–Hirschman) Index, where values over 1,500 indicate market concentration, the fourth the shannon exponential, or effective number of trade partners, the fifth the normalized number of effective trade partners (0–1), with lower values indicating skewed distributions, and he sixth the the Gini coefficient, where 1 means 1 per cent of countries supply 100 per cent of the good, and 0 means equal contribution from all countries, of agri-food products at the HS-6 level.

from substantially lower numbers of trade partners, higher HHI values and lower normalized effective numbers. Lower-income countries exhibit a narrow range of trading partners and commodities and are more often heavily reliant on a small number of export destinations or products. This lack of diversification could make these countries more susceptible to shocks in global markets. In contrast, higher-income countries could be more resilient through more evenly distributed trade flows and a broader network of trading partners, as indicated by their lower concentration metrics and greater normalized effective numbers.

Grains and oilseed trade is the most concentrated and uneven, while processed food trade is the least concentrated and most even. Figure 4 exhibits the diversification indicators by several food commodity groups. Grains and oilseeds consistently show the highest HHI values and the lowest normalized effective numbers among all food groups, reflecting highest concentration and unevenness in trade flows. These categories are heavily reliant on a few key exporters. For instance, the USA and Brazil dominate exports of corn and soybeans and India exports of rice. The Gini coefficients for these categories are also among the highest, further underscoring the inequality in trade distribution. Conversely, processed foods exhibit the lowest concentration and the most even trade flows, as evidenced by their lower HHI values and higher normalized effective numbers. This suggests that processed foods benefit from a broader base of producers and a more equitable distribution of trade shares. This finding aligns with Reardon *et al.* (2009, 2003), who highlight the spread of downstream processing and retailing capacity across developing and emerging economies through FDI and supermarket-led value chains. One reason may be that food processing faces fewer geographical restrictions compared with crop cultivation, or perhaps less home bias of consumers for processed foods (Luckstead, 2024). The contrast between staple commodities and processed foods suggests that food value chains are most vulnerable at the processing stage.

3. Empirical model

One measure that is related to the resilience of food systems is food price volatility. As prices reflect the relationship between supply and demand, frequently changing prices—upwards and downwards—reflect frequent changes in supply relative to demand. For consumers, high price volatility implies less certainty about food access, while for producers high food price volatility may imply less certainty about access to key inputs and less certainty about output sales (e.g. Bellemare *et al.*, 2013).

Both sharp food price hikes and drops can pose challenges to food security, their impact depending on whether a population is a net food buyer or seller (Swinnen and Squicciarini, 2012). However, regardless of direction, high price volatility undermines economic stability, discourages investment in agriculture and increases uncertainty in food markets (Gilbert and Morgan, 2010). Persistent fluctuations—whether upward or downward—can signal increasing vulnerability, as volatility erodes predictability for both producers and consumers. Figuratively, it is also similar to both ecological and financial systems, where volatility can be a strong indicator of weakening stability often observed before collapse (Dai *et al.*, 2015).

I estimate the relationship between trade concentration and food price volatility at the country level. To account for serial correlation in prices and to control for time-invariant country fixed effects, I transform all variables into first differences (Millimet and Bellemare, 2023; Christian and Barrett, 2024). The baseline model regresses the coefficient of within-year food price variation (ΔCV_{it}^{p}) on the diversification of import and export diversification of agri-food sectors, i.e.

$$\Delta CV_{it}^{p} = \beta_1 \Delta H(S_{ijt}^{X,M}) + \gamma_1' \Delta X_{it} + \eta_t + e_{it}. \tag{6}$$

I use import (M) and export (X) shares (s) of trade partner countries (j) to measure exposure to foreign supply shocks and foreign demand shocks, respectively, and apply several functions H that yield different diversification measures. I also account for control variables (X_{it}) and time fixed effects.

3.1 Prices

There are a multitude of price volatility measures available (e.g. Prakash, 2011; Brümmer *et al.*, 2016). Ott (2014) differentiates between within-year and interyear measures of volatility. While the latter is often measured through parametric, high-frequency time series models, the former is commonly used to measure the contributions of specific items to overall inflation.[3] While the standard deviation can be measured over any window or rolling windows, the 12-month, within-year version is particularly useful when linking volatility to trade data at the annual level. Moreover, the primary objective is to capture short–term food–price stress, or episodes which erode purchasing power, which, in practice, includes both month–to–month noise and within–year food–specific inflation, as opposed to longer-term trends.

Food price data are sourced from the FAOSTAT monthly food consumer price index (FCPI) database.[4] This data set tracks the overall changes in food costs over time, reflecting year-over-year inflation relative to the same month in the prior year. I calculate the mean-standardized CV i.e.,

$$CV_{it}^{p} = \frac{\sigma_{pmt}}{\mu_{pt}}, \tag{7}$$

of the monthly (m) FCPI observations (p) within each calendar year (t) and standardized by the mean annual FCPI (μ_{pt}) as the measure of food price volatility. The within-year CV of FCPI is a standardized measure that captures within-year price instability while maintaining comparability across countries and years. While FCPI is nonstationary over long periods, it is a normalized index with a fixed base year, and variation across twelve monthly observations is meaningful for short-run volatility. Similar summary measures are widely used in policy diagnostics and price stability assessments, particularly when absolute price data are unavailable (Gilbert and Morgan, 2010; Bellemare, 2015). I avoid deflating the FCPI by the headline CPI. Food prices constitute 20–60 per cent of headline CPI in many sample countries, making CPI a post-treatment variable as deflating FCPI by CPI mechanically removes food price variation attributable to the trade diversification channel (Cinelli *et al.*, 2024).

3.2 Diversification measures

I use three indices to measure diversification. (i) The number of trade partners (D_0), (ii) the Shannon entropy (D_1), i.e. the effective number of trade partners, which equally weighs the number of trade partners and their importance to total trade and (iii) the HHI index (D_2), which gives more weight to large contributors to total trade than to the number of trade partners. In expectation, D_0 and D_1 should have a negative effect on food price volatility. The simple count of trade partners (D_0) captures the extensive-margin trade but ignores intensity and should have a smaller effect on volatility than D_1 or D_2. The *effective number* (D_1) relates perhaps most directly to risk hedging because it captures both intensive and extensive margins equally. The HHI

3 For instance, the European Central Bank (ECB) uses the standard deviation of within-year price indices of CPI items to measure volatility inflation (e.g. Nickel *et al.*, 2025).

4 Data available at https://www.fao.org/faostat/en/#data/CP.

(D_2) should show positive effects on food price volatility as higher values indicate more concentration, with 1 indicating perfect concentration. However, it is especially sensitive to dominance (tail risk), so large shares held by a few suppliers would predict stronger shock amplification. The Gini coefficient is presented in the descriptive analysis for completeness but is not used in the econometric analysis, as its linearization is not consistent with the shift–share IV approach.

3.3 Identification

When estimating the effect of trade on food prices, several potential sources of endogeneity arise. One concern is reverse causality. Changes in food prices may influence trade flows rather than being purely a result of them. For example, higher food prices in one country could incentivize increased imports to stabilize domestic supply, leading to a two-way relationship between trade and prices. Failing to account for this bidirectional influence can lead to biased estimations of the effect of trade on food prices.

Another source of endogeneity is omitted variable bias. Factors such as weather shocks, geopolitical tensions or macroeconomic conditions can simultaneously affect trade flows and food prices. For instance, a drought in a major exporting country may reduce trade volumes while simultaneously driving up global food prices. If these factors are not properly controlled for in the econometric model, the estimated effect of trade on prices may inadvertently capture the impact of these unobserved variables, leading to spurious correlations.

Measurement error also poses a challenge. Trade data and price indices often suffer from inaccuracies due to inconsistent reporting practices, aggregation biases or limited coverage of informal trade. These errors can introduce noise into the analysis, potentially biasing coefficient estimates. Moreover, structural features of food markets, such as imperfect competition, price rigidities and strategic behaviors of large exporters or importers, can further confound the relationship.

To address the endogeneity problems in Equation (6), I construct a shift-share variable[5], where the identifying assumption is that global foreign country-sector level shocks are independent from country-level food price volatility and bilateral trade flows. The idea is to introduce exogenous variation in trade exposure through lagged trade shares and sectoral trade shocks in other countries (Borusyak *et al.*, 2025). More precisely, the global shocks, measured as the sum of foreign country-sector level shocks outside country i, are assumed to be unrelated to i's own contemporaneous shocks to food-price volatility, affecting it only by first changing i's trade composition. Let $s_{ij,t}$ be the bilateral import share from partner j and $w_{ijk,t}$ the share of sector k within

5 Section 4 of the Supplementary material provides an illustrative example of the SSIV how it captures exogenous variation in trade diversification.

the $i-j$ bilateral bundle. Exporter-sector shocks are defined as

$$g_{jk,t} \;=\; \Delta \log X_{jk,t} \;-\; \Delta \log X_{k,t}, \tag{8}$$

i.e., exporter j's sector-k growth relative to the global sector-k growth. The generic shift–share instrument is

$$Z_{it} \;=\; \sum_j \sum_k \underbrace{\left(s_{ij,t-1}\, w_{ijk,t-1}\right)}_{\text{exposure}} \; \underbrace{g_{jk,t}}_{\text{shift}} \;. \tag{9}$$

Intuitively, Z_{it} aggregates foreign shocks $g_{jk,t}$ using country-specific lagged exposure weights. In other words, the predicted change of imports (exports) is equal to the sum of all foreign export (import) shifts weighted by the bilateral sector import (export) share. Following Borusyak *et al.* (2025) the identifying assumption is the shocks $g_{jk,t}$, which are numerous given 634 commodities, 188 countries and 23 years, are orthogonal to country-specific shocks and price volatility. Standard errors are from Adao *et al.* (2019). Section 2 of the Supplementary material details how Z_{it} are mapped into an instrument for the relevant change in each diversification measure.

In high-inflation economies, food price volatility may partly reflect monetary dynamics rather than trade-driven relative price movements. However, foreign exporter-sector supply shocks are orthogonal to domestic monetary conditions by construction. E.g. a drought reducing Brazilian soybean exports relative to global trends is uncorrelated with exchange rate policy in Venezuela. Moreover, deflating the FCPI by the headline CPI is not an appropriate remedy, as food prices constitute 20–60 per cent of headline CPI in many sample countries, making CPI a post-treatment variable whose inclusion blocks part of the causal pathway of interest (Angrist and Pischke, 2009; Wooldridge, 2010; Cinelli *et al.*, 2024), while core CPIs are not broadly available and comparable for all countries in the sample. Results (available on request) are robust to excluding countries with average annual inflation exceeding 100 per cent, confirming the main finding is not driven by monetary-inflation dynamics.

3.4 Controls

While the identification strategy addresses most confounders by construction, I include controls for variables that could affect both trade composition and food prices simultaneously, potentially violating the exclusion restriction.[6] One particular confounder could be trade policy interventions, such as tariffs, embargoes and subsidies, if they systematically respond to changes in food price volatility. For example, if a country imposes import tariffs in response to food price volatility, these policies could affect both trade shares (which enter the instrument) and food prices, violating the exclusion restriction. Similarly, retaliatory measures in a trade war could introduce correlations between

6 A detailed list of all the variables used in the analysis and their sources is provided in Table 1 and the summary statistics in Table 2 of the Supplementary material.

global trade shocks and food price volatility that are not exogenous. To ensure that shifts in trade policy do not confound my results, I introduce two control variables. First, I include the number of tariff changes and nontariff barriers on agri-food products implemented from the Global Trade Alert database. Second, I include the number of regional trade agreements as another control variable capturing changes in the policy landscape.

To control for confounders on the demand side, I include measures of population size and composition, i.e., population under the age of 15, between the ages of 15 and 64, and older than 65, as well as female population and population density, which could potentially drive either or both trade structures and food prices through demand dynamics. Other time-varying variables are likely to be colliders or mediators of the relationship between trade diversification and food price volatility and their inclusion in the model might bias the estimate.

4. Results

Table 1 presents the results of the relationship between import concentration and food price stability, measured as the change in the within-year CV of monthly food prices. The F-tests for the first-stage regressions indicate that the instrument is relevant in all SSIV models, confirming the validity of the shift-share instrument. The dependent variable is the first difference of food price volatility. I evaluate the coefficients of the number and the effective number of source countries (D_0, D_1) and the HHI (D_2).

The number of source countries is negatively associated with food price volatility. The results suggest that adding one more import source country reduces food price volatility by approximately 0.04 percentage points.

The effective number of source countries (ΔD_1) (column 4) shows a much stronger negative association with food price volatility. Greater diversification, accounting for both the number and balance of import sources equally, reduces volatility. Adding one more effective source country, i.e. one that supplies inputs as evenly as others, reduces monthly food price variation by about 8.2 percentage points. The HHI (ΔD_2) coefficient in column (6) is negative, but it is imprecisely estimated and reverses sign relative to the OLS estimate.

Overall, the results emphasize the importance of import diversification in terms of evenness (intensive margin) more than in terms of richness (extensive margin), in reducing food price volatility, and the risks associated with concentration. In particular, the effective number of sources (D_1) is particularly effective in highlighting the benefits of balanced and diversified import portfolios.

Table 2 presents the results of the relationship between export concentration and food price stability, measured as the change in the CV of food prices. The F-tests for the first-stage regressions indicate that the shift–share instrument is less relevant than in the import-side SSIV specifications. Again, the dependent variable is the first difference of food price volatility, but the

Table 1. Effects of import concentration on food price stability. Shift–share IV (SSIV) models of various concentration indicators in first differences (FD)

	Δ food price CV					
Dependent variable FD	OLS (1)	SSIV (2)	OLS (3)	SSIV (4)	OLS (5)	SSIV (6)
ΔD_0^M (Number of sources)	−0.0204***	−0.0402**				
	(0.0076)	(0.0179)				
ΔD_1^M (Effective number of sources)			−1.075*	−8.154**		
			(0.6080)	(2.241)		
ΔD_2^M (Herfindahl–Hirschman concentration)					2.669	−1.640
					(2.110)	(8.680)
Controls	✓	✓	✓	✓	✓	✓
F-stat (1st stage)		1012.54		46.35		220.00
First stage estimate		0.6524***		0.2506*		0.1481***
		(0.0710)		(0.1471)		(0.0364)
Reduced form estimate		−0.0262**		−2.0431**		−0.2429
		(0.0103)		(1.0308)		(0.7517)
Observations	3,948	3,948	3,948	3,948	3,948	3,948
Year fixed effects	✓	✓	✓	✓	✓	✓
Region fixed effects	✓	✓	✓	✓	✓	✓

Notes: Standard errors for SSIV columns are AKM0 (Adao *et al.*, 2019) computed at the HS6 exporter–product shifter level and they are heteroskedasticity-robust and allow arbitrary correlation within shifters across countries. OLS columns report heteroskedasticity-robust standard errors clustered by country and year. All models are estimated in first differences and include year and region fixed effects plus controls for population (0–14, 15–64 and 65+), population density, female population share, the number of regional trade agreements, and the number of trade interventions. ***, ** and * denote significance at the 1 per cent, 5 per cent and 10 per cent levels, respectively.

Table 2. Effects of export concentration on food price stability. Shift–share IV (SSIV) models of various concentration indicators in first differences (FD)

	Δ food price CV					
Dependent variable	OLS	SSIV	OLS	SSIV	OLS	SSIV
FD	(1)	(2)	(3)	(4)	(5)	(6)
ΔD_0^X (Number of destinations)	−0.0265**	−0.0177				
	(0.0107)	(0.4456)				
ΔD_1^X (Effective number of destinations)			−0.2727	2.332		
			(0.1778)	(1.404)		
ΔD_2^X (Herfindahl–Hirschman concentration)					1.015*	−2.568
					(0.6051)	(5.175)
Controls	✓	✓	✓	✓	✓	✓
F-stat (1st stage)		632.59		19.10		59.40
First stage estimate		0.5273***		0.0589**		0.0466***
		(0.0489)		(0.0287)		(0.0122)
Reduced form estimate		−0.0094		0.1375		−0.1197
		(0.0199)		(0.1487)		(0.1664)
Observations	3,948	3,948	3,948	3,948	3,948	3,948
Year fixed effects	✓	✓	✓	✓	✓	✓
Region fixed effects	✓	✓	✓	✓	✓	✓

Notes: Standard errors for SSIV columns are AKM0 (Adao *et al.*, 2019) computed at the HS6 exporter–product shifter level and they are heteroskedasticity-robust and allow arbitrary correlation within shifters across countries. OLS columns report heteroskedasticity-robust standard errors clustered by country and year. All models are estimated in first differences and include year and region fixed effects plus controls for population (0–14, 15–64 and 65+), population density, female population share, the number of regional trade agreements, and the number of trade interventions. ***, ** and * denote significance at the 1 per cent, 5 per cent and 10 per cent levels, respectively.

coefficients in this table represent the effects on the export side, i.e. of the number of destination countries,the effective number of destination countries and the HHI index of destination countries.

The number of destination countries (ΔD_0) is negatively associated with food price volatility, although the estimate lacks precision. This suggests that having more trade partners for exports is probably not a strong driver of domestic food price volatility. The effective number of export destinations (ΔD_1) shows an inconclusive relationship with food price volatility as the OLS coefficient is negative while the SSIV estimate reverses sign and is larger in absolute magnitude, though imprecisely estimated. This indicates that evenness and richness in export destinations together might also not play a dominant role in stabilizing food prices. For the HHI (ΔD_2), the OLS coefficient is positive and marginally significant, while the SSIV estimate reverses sign and is imprecisely estimated, again pointing to an inconclusive relationship on the export side. Thus, the implications for less concentration in agri-food exports are inconclusive, and the magnitude and precision of the estimates vary considerably between import and export sides.

Section 5.1 of the Supplementary material provides a test of whether the effects differ for countries of different income groups. The largest reductions in volatility are observed for lower- and upper-middle-income countries. High-income countries show a smaller, insignificant effect, and low-income countries a weak first stage. Sectoral results in Section 5.2 of the Supplementary material indicate that processed foods exhibit the weakest relationship with volatility, likely due to flexible supply chains, while animal products, particularly in exports, show stronger associations, suggesting that regulatory and logistical constraints heighten vulnerability to concentration risks.

The robustness of these results hinges on the validity of the SSIV approach. In Section 3 of the Supplementary material, I conduct several tests addressing key identification concerns. First, I investigate instrument relevance by examining the first stage and reduced form of the SSIV against trade concentration measures and food price volatility. The results confirm a strong first-stage relationship and correlation between the instrument and the outcome. Second, following Adao *et al.* (2019), I implement a placebo outcome test using future food price volatility, finding no significant predictive power of the instrument beyond its contemporaneous effects, supporting its exogeneity. Third, I conduct a balance test for pre-trends to rule out that the instrument is correlated with past food price volatility changes (e.g. Autor *et al.*, 2013; Goldsmith-Pinkham *et al.*, 2020), again confirming no systematic relationship.

5. Policy implications

My findings suggest that international agri-food trade is concentrated, which translates into domestic price volatility and thus may compromise the resilience of food systems. In particular, diversification of import origins, in terms of both richness and evenness, is associated with improved food price stability, but the evidence on export destinations is less robust compared with the import side.

The concentration of imports is in line with trade theory. Countries specialize in exporting goods in which they have a comparative advantage, thereby maximizing efficiency gains. In absence of product differentiation effects as it is the case for processed foods, bulk commodities, which often also serve as inputs for processed food products, specialization may create dependencies on a limited set of source countries, amplifying the risks of supply-side and policy shocks and their propagation. The descriptive results suggest that this is in particular true for grains and oil seeds, which serve as staple foods or key inputs for downstream food products. While specialization increases global welfare in absence of uncertainty, it may come at the cost of higher volatility in the presence of random shocks.

While trade relationships often rewire in response to shocks (Haqiqi and Hertel, 2026), it takes time to find alternative suppliers and shipping, switching costs are non-zero, and often times many buyers are competing for supplies from few places. Thus, even though eventually shifting comparative advantages will lead to a new equilibrium, these factors put short-term upward pressure on prices which, while temporary, might be substantial. Moreover, once other suppliers increase production and exports, the supply response may again lead to strong downward pressure on commodity and domestic food prices, increasing price volatility.

Policy responses to food market and international supply chain risks usually focus on self-sufficiency and involve restrictive trade measures, such as export tariffs, quotas or bans, or subsidizing domestic production in an effort to onshore production. For example, during the 2008 global food crisis and the severe 2012 drought in the US Corn Belt, many countries implemented export restrictions to stabilize domestic markets. India implemented a rice export ban in 2023 in response to rising domestic food prices. More recently, the US Inflation Reduction Act allocated $370 billion in subsidies to incentivize on-shoring of key industries. While these policies may reduce domestic short-term price volatility, they add at best one more supplier to the portfolio of import countries, and thus only marginally improve longer-term volatility. Moreover, a body of literature has shown that unilateral price insulation policies are likely to exacerbate global market instability even further (e.g. Anderson and Nelgen, 2012; Martin and Anderson, 2012; Pieters and Swinnen, 2016; Berger *et al.*, 2021; Alfaro and Chor, 2023).

Food self-sufficiency policy creates another layer of uncertainty and is itself costly in terms of higher domestic prices, infrastructure and welfare in general. Clapp (2017) emphasizes that food self-sufficiency may be warranted in cases of high import dependency, it is not a panacea, and might even harm food security in low-income countries due to lower efficiency in production. Moreover, the potential of food self-sufficiency is naturally limited by natural endowments, as not *every* country hosts suitable areas for *all* food products (Pietrzak *et al.*, 2019; Dalheimer *et al.*, 2026a).

The empirical evidence supports the predictions of Elliott *et al.* (2022) and the empirical results of Hadachek and Ma (2024) for the agri-food sector, who argue that the trade-off between efficiency and resilience highlights an externality in the formation of trade networks. Decentralized decision-making in supply network formation often results in outcomes that are efficient for individuals but suboptimal for the collective system. For example, agribusinesses might maximize profits in the short term by concentrating input supplies in firms and countries that offer the lowest costs, and less so by diversifying their import portfolio to protect against unforeseen shocks, while consumers, industries and governments benefit from the stability of domestic production and consumption. Indeed, on the export side Fiankor (2023) and Arkolakis and Muendler (2013) have shown that firms maximize profits when trading with relatively few partners. As risk preferences of individual agribusinesses and consumers differ, so do their marginal benefits. Thus, concentrated trade relationships which increase price volatility by amplifying the propagation of shocks may create negative externalities that are not internalized by individual actors.

In designing policy intervention to increase resilience of food systems, it is critical to account for the incentive structure faced by agribusinesses in foreign sourcing. Policies should prioritize coordinated international efforts rather than unilateral measures that may further destabilize global trade networks. Diversification policies that balance the trade-offs between efficiency and resilience offer a more sustainable approach to mitigating the risks inherent in concentrated food supply chains. For instance, Pigouvian taxes or subsidies, such as those proposed in Grossman *et al.* (2023), are one option to internalize the external costs of volatility from concentrated trade and allow to harness both the benefits of diversity as well as the gains in efficiency generated through international trade and specialization. Such measures keep multiple soft and hard infrastructure available and simultaneously lead to competitiveness of more suppliers. Both reduce switching and time cost in case of unexpected shocks.

6. Conclusion

Recent disruptions to agri-food input and output markets such as volatile food retail and commodity prices, soaring fertilizer prices and shortages of labor highlight yet again how international trade is interlinked with food systems resilience and price volatility. On the one hand, international trade allows sourcing and marketing food inputs and outputs from and to a larger pool of suppliers and consumers and offers increased efficiency in production through the gains-from-trade, potentially buffering food systems against large shocks. On the other hand, international specialization may lead input and output markets to be more concentrated geographically and thus exposing food systems to risks. While domestic firm-level evidence has shown that concentration in few firms has been shown to increase food price volatility and reduce resilience, the effect of import and export concentration is unclear. To address this gap, first, I compile several country-level indicators of import and export concentration and describe international import and export structures. Second, I evaluate descriptive patterns of food trade concentration across time and countries. Third, I estimate the effect of the diversification indicators on country level food price volatility.

This paper offers four key findings. First, international food trade is not diversified. Although most countries could in principle source from or sell to a large number of partners, actual trade volumes are concentrated among only a handful of them. Second, this is not because countries lack potential trading connections, but because trade volumes are unevenly distributed among the partners they do have. Third, this concentration is heterogeneous across countries, commodities and time. It is more pronounced for lower-income countries than for higher-income countries, and for primary commodities such as grains and oilseeds than for processed foods, and it has been rising again since 2016 after a long period of increasing diversification. These patterns suggest that the countries and commodities least equipped to absorb shocks, i.e. poorer economies and staple crops, are also the most exposed to concentrated trade structures.

Fourth, using a SSIV approach, I find that food price volatility is strongly associated with trade concentration. This association is stronger for the evenness of trade shares than for the sheer number of trading partners, confirming that the balance of a country's sourcing matters more for stability than the breadth of its supplier network. The effect is also asymmetric between the import and export side: diversifying import sources has a large and statistically robust stabilizing effect on food prices, with one additional effective import source associated with a reduction in food price volatility of roughly 8.2 percentage points, while diversifying export destinations shows a comparatively weak and inconclusive relationship with volatility. This asymmetry suggests that domestic food price stability depends primarily on how evenly a country sources its imports, rather than on how widely it distributes its exports.

These results emphasize the importance of trade diversification in reducing food price volatility and thereby enhancing a key component of food system resilience. Similar to portfolio diversification, increasing the number of trading partners and balancing trade shares can mitigate exposure to idiosyncratic shocks. Rather than focusing on self-sufficiency, which adds at best one more supplier, policy should prioritize adding multiple sources and destinations to trade networks. However, such diversification involves trade-offs, as concentration arises naturally from specialization and the associated efficiency gains. Thus, policies should aim to maximize both the gains from international specialization and the diversity of international markets. One specific option could be Pigou-type subsidies or taxes to internalize trade risks through international diversification rather than nationalization of food production.

Acknowledgements

I thank the Editor Alessandro Olper and four anonymous reviewers for helpful comments. I am grateful to Marc F. Bellemare, Dela Dem Doe Fiankor, Marley Heritier, Marie Kammer, Meilin Ma, Andrew Stevens, Yutaro Inoue and participants of the 2025 annual meeting of the Canadian Agricultural Economics Society for useful comments and suggestions. All remaining errors are mine.

Supplementary material

Supplementary data is available at *ERAE* online.

Conflicts of interest. None declared.

Funding

None declared.

References

Adao, R., Kolesár, M., and Morales, E. (2019). 'Shift-Share Designs: Theory and Inference', *The Quarterly Journal of Economics*, 134: 1949–2010. https://doi.org/10.1093/qje/qjz025

Adelman, M. A. (1969). 'Comment on the "H" Concentration Measure As A Numbers-Equivalent', *The Review of Economics and Statistics*, 51: 99–101. https://doi.org/10.2307/1926955

Alfaro, L., and Chor, D. (2023). 'Global Supply Chains: The Looming Great Reallocation', Cambridge: National Bureau of Economic Research. https://doi.org/10.3386/w31661

Allen, T., and Atkin, D. (2022). 'Volatility and the Gains from Trade', *Econometrica*, 90: 2053–92. https://doi.org/10.3982/ECTA14411

Amodio, F. et al. (2024). 'Weather Shocks Affect Trade Policy: Evidence from Preferential Trade Agreements', *American Journal of Agricultural Economics*, 107: 696–717.

Anderson, K., and Nelgen, S. (2012). 'Trade Barrier Volatility and Agricultural Price Stabilization', *World Development*, 40: 36–48. https://doi.org/10.1016/j.worlddev.2011.05.018

Anderson, K., Rausser, G., and Swinnen, J. (2013). 'Political Economy of Public Policies: Insights from Distortions To Agricultural and Food Markets', *Journal of Economic Literature*, 51: 423–77. https://doi.org/10.1257/jel.51.2.423

Angrist, J. D., and Pischke, J.-S. (2009). *Mostly Harmless Econometrics: An Empiricist's Companion*. Princeton: Princeton University Press.

Appelbaum, E., and Kohli, U. (1997). 'Import Price Uncertainty and the Distribution of Income', *Review of Economics and Statistics*, 79: 620–30. https://doi.org/10.1162/003465397557024

Appelbaum, E., and Kohli, U. (1998). 'Import-Price Uncertainty, Production Decisions, and Relative Factor Shares', *Review of International Economics*, 6: 345–60. https://doi.org/10.1111/1467-9396.00108

Arita, S. et al. (2022). 'Has Global Agricultural Trade Been Resilient Under Coronavirus (Covid-19)? Findings from an Econometric Assessment of 2020', *Food Policy*, 107: 102204. https://doi.org/10.1016/j.foodpol.2021.102204

Arkolakis, C., and Muendler, M.-A. (2013). 'Exporters and Their Products: A Collection of Empirical Regularities', *CESifo Economic Studies*, 59: 223–48. https://doi.org/10.1093/cesifo/ifs028

Autor, D. H., Dorn, D., and Hanson, G. H. (2013). 'The China Syndrome: Local Labor Market Effects of Import Competition in the United States', *American Economic Review*, 103: 2121–68, https://doi.org/10.1257/aer.103.6.2121.

Baqaee, D. R., and Farhi, E. (2024). 'Networks, Barriers, and Trade', *Econometrica*, 92: 505–41. https://doi.org/10.3982/ECTA17513

Batra, R. N., and Russell, W. R. (1974). 'Gains from Trade Under Uncertainty', *The American Economic Review*, 64: 1040–48.

Beck, A., Lim, S., and Taglioni, D. (2024). 'Understanding firm Networks in Global Agricultural Value Chains', *Food Policy*, 127: 102689. https://doi.org/10.1016/j.foodpol.2024.102689

Bellemare, M. F. (2015). 'Rising Food Prices, Food Price Volatility, and Social Unrest', *American Journal of Agricultural Economics*, 97: 1–21. https://doi.org/10.1093/ajae/aau038

Bellemare, M. F., Barrett, C. B., and Just, D. R. (2013). 'The Welfare Impacts of Commodity Price Volatility: Evidence from Rural Ethiopia', *American Journal of Agricultural Economics*, 95: 877–99. https://doi.org/10.1093/ajae/aat018

Bemelmans, J. et al. (2023). 'Trade Effects of Voluntary Sustainability Standards in Tropical Commodity Sectors', *Food Policy*, 118: 102440. https://doi.org/10.1016/j.foodpol.2023.102440

Berger, J., Dalheimer, B., and Brümmer, B. (2021). 'Effects of Variable EU Import Levies on Corn Price Volatility', *Food Policy*, 102: 102063. https://doi.org/10.1016/j.foodpol.2021.102063

Borusyak, K., Hull, P., and Jaravel, X. (2025). 'A Practical Guide to Shift-Share Instruments', *Journal of Economic Perspectives*, 39: 181–204. https://doi.org/10.1257/jep.20231370

Brümmer, B. et al. (2016). *Agricultural Markets Instability: Revisiting the Recent Food Crises*, London: Routledge.

Christian, P., and Barrett, C. B. (2024). 'Spurious Regressions and Panel IV Estimation: Revisiting the Causes of Conflict', *The Economic Journal*, 134: 1069–99. https://doi.org/10.1093/ej/uead091

Cinelli, C., Forney, A., and Pearl, J. (2024). 'A Crash Course in Good and Bad Controls', *Sociological Methods & Research*, 53: 1071–104. https://doi.org/10.1177/00491241221099552

Clapp, J. (2017). 'Food Self-Sufficiency: Making Sense of it, and When it Makes Sense', *Food Policy*, 66: 88–96, https://doi.org/10.1016/j.foodpol.2016.12.001.

Clapp, J. (2023). 'Concentration and Crises: Exploring the Deep Roots of Vulnerability in the Global Industrial Food System', *The Journal of Peasant Studies*, 50: 1–25. https://doi.org/10.1080/03066150.2022.2129013

Dai, L., Korolev, K. S., and Gore, J. (2015). 'Relation between Stability and Resilience Determines the Performance of Early Warning Signals under Different Environmental Drivers', *Proceedings of the National Academy of Sciences*, 112: 10056–61. https://doi.org/10.1073/pnas.1418415112

Dalheimer, B., and Bellemare, M. F. (2026). 'Global Agricultural Value Chains and Food Prices', *American Journal of Agricultural Economics*. https://doi.org/10.1111/ajae.70030

Dalheimer, B., Bellemare, M. F., and Loughmiller, W. (2026a). 'The Geopolitics of Food and Agriculture', *Annual Review of Resource Economics*, 18. https://doi.org/10.1146/annurev-resource-112624-010824

Dalheimer, B. et al. (2026b). 'Stocks and Shocks: Assessing the Relative Roles of Public and Private Inventories in Buffering Rice Price Volatility in the philippines', *Food Policy*, 139: 103052. https://doi.org/10.1016/j.foodpol.2026.103052

Elliott, M., Golub, B., and Leduc, M. V. (2022). 'Supply Network Formation and Fragility', *American Economic Review*, 112: 2701–47. https://doi.org/10.1257/aer.20210220

Feder, G., Just, R., and Schmitz, A. (1977). 'Storage with Price Uncertainty in International Trade', *International Economic Review*, 1: 553–68.https://doi.org/10.2307/2525948

Fedoseeva, S., and Herrmann, R. (2019). 'The Price of Sanctions: An Empirical Analysis of German Export Losses Due to the Russian Agricultural Ban', *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, 67: 417–31. https://doi.org/10.1111/cjag.12194

Fiankor, D.-D. D. (2023). 'Distance to Destination and Export Price Variation within Agri-Food Firms', *European Review of Agricultural Economics*, 50: 563–90. https://doi.org/10.1093/erae/jbac018

Fiankor, D.-D. D., Dalheimer, B., and Mack, G. (2024). 'Pesticide Regulatory Heterogeneity, Foreign Sourcing, and Global Agricultural Value Chains', *American Journal of Agricultural Economics*, 107: 611–34.

Gaigné, C., and Gouel, C. (2022). 'Trade in Agricultural and Food Products', *Handbook of Agricultural Economics*, 6: 4845–931. https://doi.org/10.1016/bs.hesagr.2022.03.004

Gaulier, G., and Zignago, S. (2010). 'BACI: International Trade Database at the Product-Level. the 1994–2007 Version', CEPII, Working Papers. Paris: CEPII. https://doi.org/10.2139/ssrn.1994500

Gervais, A. (2018). 'Uncertainty, Risk Aversion and International Trade', *Journal of International Economics*, 115: 145–58. https://doi.org/10.1016/j.jinteco.2018.09.001

Gervais, A. (2021). 'Global Sourcing under Uncertainty', *Canadian Journal of Economics/Revue canadienne d'économique*, 54: 1103–35. https://doi.org/10.1111/caje.12516

Gilbert, C. L., and Morgan, C. W. (2010). 'Food Price Volatility', *Philosophical Transactions of the Royal Society B*, 365: 3023–34, https://doi.org/10.1098/rstb.2010.0139.

Goldsmith-Pinkham, P., Sorkin, I., and Swift, H. (2020). 'Bartik Instruments: What, When, Why, and How', *American Economic Review*, 110: 2586–624, https://doi.org/10.1257/aer.20181047.

Gouel, C. (2012). 'Agricultural Price Instability: A Survey of Competing Explanations and Remedies', *Journal of Economic Surveys*, 26: 129–56. https://doi.org/10.1111/j.1467-6419.2010.00634.x

Gouel, C. (2014). *Food Price Volatility and Domestic Stabilization Policies in Developing Countries*, Chicago: University of Chicago Press.

Gouel, C. (2016). 'Trade Policy Coordination and Food Price Volatility', *American Journal of Agricultural Economics*, 98: 1018–37. https://doi.org/10.1093/ajae/aaw020

Gouel, C., and Wright, B. D. (2026). ‘Storage and the Economics of Commodity Price Stabilization’, *Annual Review of Resource Economics*, 18. https://doi.org/10.1146/annurev-resource-112624-121752

Grossman, G. M., Helpman, E., and Lhuillier, H. (2023). ‘Supply Chain Resilience: Should Policy Promote International Diversification or Reshoring?’, *Journal of Political Economy*, 131: 3462–96. https://doi.org/10.1086/725173

Hadachek, J., and Ma, M. (2024). ‘Risk Management Externalities in Food Supply Chains (December 23, 2024)’, Available at SSRN: https://ssrn.com/abstract=5143693 or http://dx.doi.org/10.2139/ssrn.5143693

Hadachek, J., Ma, M., and Sexton, R. J. (2024). ‘Market Structure and Resilience of Food Supply Chains Under Extreme Events’, *American Journal of Agricultural Economics*, 106: 21–44. https://doi.org/10.1111/ajae.12393

Haqiqi, I., and Hertel, T. (2026). ‘The Buffer Value of Trade: Quantifying How Global Integration Stabilizes Food Prices and Farm Incomes’, *Food Security*, 18: 1–27.

Hill, M. O. (1973). ‘Diversity and Evenness: A Unifying Notation and Its Consequences’, *Ecology*, 54: 427–32. https://doi.org/10.2307/1934352

Hoffmann, C. et al. (2026). ‘Food Price Crises and the Insulation of Domestic Grain Markets’, *Agricultural Economics*, 57: e70125. https://doi.org/10.1111/agec.70125

Jayne, T. S., Zulu, B., and Nijhoff, J. (2006). ‘Stabilizing Food Markets in Eastern and Southern Africa’, *Food Policy*, 31: 328–41. https://doi.org/10.1016/j.foodpol.2006.03.008

Josling, T., and Tangermann, S. (1999). ‘Implementation of the wto Agreement on Agriculture and Developments for the Next Round of Negotiations’, *European Review of Agricultural Economics*, 26: 371–88. https://doi.org/10.1093/erae/26.3.371

Jost, L. (2006). ‘Entropy and Diversity’, *Oikos*, 113: 363–75. https://doi.org/10.1111/j.2006.0030-1299.14714.x

Karakoc, D. B., and Konar, M. (2021). ‘A Complex Network Framework for the Efficiency and Resilience Trade-off in Global Food Trade’, *Environmental Research Letters*, 16: 105003. https://doi.org/10.1088/1748-9326/ac1a9b

Kiloes, A. M. et al. (2024). ‘Unravelling the Provisioning System of a Strategic Food Commodity To Minimise Import Dependency: A Study of Garlic in Indonesia’, *Food Policy*, 123: 102604. https://doi.org/10.1016/j.foodpol.2024.102604

Kummu, M. et al. (2020). ‘Interplay of Trade and Food System Resilience: Gains on Supply Diversity Over Time at the Cost of Trade Independency’, *Global Food Security*, 24: 100360. https://doi.org/10.1016/j.gfs.2020.100360

Larch, M., Luckstead, J., and Yotov, Y. V. (2024). ‘Economic Sanctions and Agricultural Trade’, *American Journal of Agricultural Economics*, 106: 1477–517. https://doi.org/10.1111/ajae.12473

Limão, N., and Maggi, G. (2015). ‘Uncertainty and Trade Agreements’, *American Economic Journal: Microeconomics*, 7: 1–42. https://doi.org/10.1257/mic.20130163

Luckstead, J. (2024). ‘Globalisation and Agri-Food Trade’, *European Review of Agricultural Economics*, 51: 32–53. https://doi.org/10.1093/erae/jbad038

Ma, M., and Lusk, J. L. (2021). ‘Concentration and Resilience in the us Meat Supply Chains’, Cambridge: National Bureau of Economic Research.

Martin, W., and Anderson, K. (2012). ‘Export Restrictions and Price Insulation During Commodity Price Booms’, *American Journal of Agricultural Economics*, 94: 422–27. https://doi.org/10.1093/ajae/aar105

Martin, W., Mamun, A., and Minot, N. (2026). ‘Implications of Food Trade Policy for Domestic and International Food Price Volatility’, *Agricultural Economics*, 57: e70101. https://doi.org/10.1111/agec.70101

Millimet, D. L., and Bellemare, M. F. (2023). 'Fixed Effects and Causal Inference', Bonn: IZA. https://doi.org/10.2139/ssrn.4467963

Nes, K. et al. (2025a). 'Extreme Weather Events, Climate Expectations, and Agricultural Export Dynamics', *American Journal of Agricultural Economics*, 107: 826–845. https://doi.org/10.1111/ajae.12505

Nes, K., Schaefer, K. A., and Yu, J. (2025b). 'Economic Impacts of the Indian Ban on Non-Basmati Rice Exports', *Food Policy*, 134: 102893. https://doi.org/10.1016/j.foodpol.2025.102893

Newbery, D. M., and Stiglitz, J. E. (1984). 'Pareto Inferior Trade', *The Review of Economic Studies*, 51: 1–12.

Nickel, C. et al. (2025). 'A Strategic View on the Economic and Inflation Environment in the Euro Area', Occasional Paper Series, No. 371. Frankfurt am Main: European Central Bank.

Novy, D., and Taylor, A. M. (2020). 'Trade and Uncertainty', *Review of Economics and Statistics*, 102: 749–65.

Ott, H. (2014). 'Volatility in Cereal Prices: Intra-Versus Inter-Annual Volatility', *Journal of Agricultural Economics*, 65: 557–78.

Patil, G., and Taillie, C. (1982). 'Diversity as a Concept and its Measurement', *Journal of the American statistical Association*, 77: 548–61. https://doi.org/10.1080/01621459.1982.10477845

Pieters, H., and Swinnen, J. (2016). 'Trading-off Volatility and Distortions? Food Policy During Price Spikes', *Food Policy*, 61: 27–39. https://doi.org/10.1016/j.foodpol.2016.01.004

Pietrzak, M., Łapińska, K., and Balcerzak, W. (2019). 'Food Security and Food Self-Sufficiency Around the World: A Typology of Countries', *PLOS ONE*, 14: e0213448, https://doi.org/10.1371/journal.pone.0213448.

A. Prakash, (2011). *Safeguarding Food Security in Volatile Global Markets*. 1st edn. Rome: Food and Agriculture Organization of the United Nations (FAO).

Puma, M. J. (2019). 'Resilience of the Global Food System', *Nature Sustainability*, 2: 260–61. https://doi.org/10.1038/s41893-019-0274-6

Raimondi, V. et al. (2023). 'Impact of Global Value Chains on Tariffs and Non-Tariff Measures in Agriculture and Food', *Food Policy*, 118: 102469. https://doi.org/10.1016/j.foodpol.2023.102469

Reardon, T. et al. (2003). 'The Rise of Supermarkets in Africa, Asia, and Latin America', *American Journal of Agricultural Economics*, 85: 1140–46. https://doi.org/10.1111/j.0092-5853.2003.00520.x

Reardon, T. et al. (2009). 'Agrifood Industry Transformation and Small Farmers in Developing Countries', *World Development*, 37: 1717–27. https://doi.org/10.1016/j.worlddev.2008.08.023

Richards, T. J., Ubilava, D., and Polyviou, M. (2025). 'Market Concentration and Resilience in Agricultural Supply Chains (December 15, 2025)', Available at SSRN: https://ssrn.com/abstract=6023034 or http://dx.doi.org/10.2139/ssrn.6023034

Rude, J., and An, H. (2015). 'Explaining Grain and Oilseed Price Volatility: The Role of Export Restrictions', *Food Policy*, 57: 83–92, https://doi.org/10.1016/j.foodpol.2015.09.002.

Saitone, T. L. et al. (2024). 'Consolidation and Concentration in us Meat Processing: Updated Measures using Plant-Level Data', *Review of Industrial Organization*, 64: 35–56. https://doi.org/10.1007/s11151-023-09923-z

Schaefer, K. A., and Wolf, C. A. (2025). 'Trade Protection Via Tariff Rate Quota Administration', *Food Policy*, 131: 102801. https://doi.org/10.1016/j.foodpol.2025.102801

Seekell, D. et al. (2017). 'Resilience in the Global Food System', *Environmental Research Letters*, 12: 025010. https://doi.org/10.1088/1748-9326/aa5730

Stevens, A. W., and Teal, J. (2024). 'Diversification and Resilience of Firms in the Agrifood Supply Chain', *American Journal of Agricultural Economics*, 106: 739–78. https://doi.org/10.1111/ajae.12398

Swinnen, J., and Squicciarini, P. (2012). 'Mixed Messages on Prices and Food Security', *Science*, 335: 405–6. https://doi.org/10.1126/science.1210806

Tendall, D. M. et al. (2015). 'Food System Resilience: Defining the Concept', *Global Food Security*, 6: 17–23. https://doi.org/10.1016/j.gfs.2015.08.001

Tian, J. (2026). 'Identifying the Causal Impacts of International Sanctions on Agricultural Trade: An Event Study Approach', *Journal of Agricultural Economics*, 1–13. https://doi.org/10.1111/1477-9552.70071

Turnovsky, S. J. (1974). 'Technological and Price Uncertainty in a Ricardian Model of International Trade', *The Review of Economic Studies*, 41: 201–17. https://doi.org/10.2307/2296713

Villoria, N. B. (2025). 'Trade Frictions and Domestic Food Price Stability in the Presence of Large-Scale Climate Shocks', *American Journal of Agricultural Economics*, 108. https://doi.org/10.1111/ajae.12531.

Wahdat, A. Z., and Lusk, J. L. (2023). 'The Achilles Heel of the us Food Industries: Exposure to Labor and Upstream Industries in the Supply Chain', *American Journal of Agricultural Economics*, 105: 624–43. https://doi.org/10.1111/ajae.12331

Wang, Z., and Liu, H. (2023). 'Can Export Market Diversification Mitigate Agricultural Export Volatility? A Trade Network Perspective', *Emerging Markets Finance and Trade*, 59: 2234–51. https://doi.org/10.1080/1540496X.2023.2171725

Wooldridge, J. M. (2010). *Econometric Analysis of Cross Section and Panel Data*. Cambridge: MIT press.