The University of Tehran Press

Journal of Iran and Central Eurasia Studies

Online ISSN: 2645-6060

Home Page: https://ijces.ut.ac.ir

Analysis of agricultural trade network between the Association of Southeast Asian Nations (ASEAN) and the Eurasian Economic Union (EAEU)

Ali Fakour[1*] | Ali Gholamnia[2]

1. Corresponding Author, Department of Economics, Faculty of Resistance Economics, Imam Hossein University, Tehran, Iran. Email: Fakourali28@gmail.com
2. Department of Economics, Faculty of Resistance Economics, Imam Hossein University, Tehran, Iran. Email: Aligholamnia22@gmail.com

ARTICLE INFO

Article type:
Research Article

Article History:
Received 20 May 2025
Revised 18 August 2025
Accepted 29 August 2025
Published Online 29 August 2025

Keywords:
Agricultural Policies,
Trade Agreements,
Tariffs and Trade Barriers,
Trade Balance,
Regional Food Security.

ABSTRACT

Achieving international food security requires a deeper understanding of the global agricultural trade networks that connect countries through imports and exports. With the volume and value of agricultural trade increasing annually, optimizing these international networks is crucial for global nutrition. Key to this optimization is the development of transportation infrastructure, such as trade corridors, and advancements in agricultural logistics, particularly between the Eurasian Economic Union (EAEU) and the Association of Southeast Asian Nations (ASEAN). This study uses network analysis to examine the trade network positions of the EAEU and ASEAN in five major grain categories: wheat, rice, barley, oilseeds, and corn, using data from 2023. The objective is to identify key players and analyze the overall structure of this trade network. The findings reveal that the networks from 2023 are characterized by a power distribution and a high clustering coefficient. The analysis of the intermediate centrality index identifies Kazakhstan within the EAEU, and Vietnam and Indonesia within ASEAN, as highly influential players in the trade of these essential agricultural products. This research highlights the necessity of leveraging the capabilities of these unions to optimize agricultural trade. The insights gained are valuable for understanding past trends and emerging dynamics in the global agricultural commodity system, particularly in the face of potential trade shocks. This understanding can inform policy and strategic initiatives aimed at enhancing worldwide food security by making the international flow of agricultural products more resilient and efficient.

Cite this article: Fakour, A. & Gholamnia, A. (2025). Analysis of agricultural trade network between the Association of Southeast Asian Nations (ASEAN) and the Eurasian Economic Union (EAEU). *Journal of Iran and Central Eurasia Studies*, 8 (1), 143-160. DOI: http//doi.org/10.22059/jices.2025.395676.1092

Publisher: University of Tehran Press.
DOI: http//doi.org/10.22059/jices.2025.395676.1092

1. Introduction

Food production and trade are interconnected through a global network of interdependencies, which makes it possible to estimate how a production shock in one country might indirectly affect many others. This study focuses on the international trade of staple foods—specifically, wheat, barley, rice, maize, and oilseeds—which are crucial sources of calories worldwide.

In the era of globalization, the volume and value of international trade have grown dramatically. While organizations like the World Trade Organization (WTO) promote multilateral cooperation, regional blocs have become increasingly important to countries' economic development strategies. For nations in peripheral areas, particularly those in the Eurasian Economic Union (EAEU) and ASEAN, leveraging both global and regional resources is essential for achieving national prosperity and ensuring food security.

The agricultural sector is vital for global food security, and understanding the complexities of its trade networks is paramount. The ASEAN region is a major agricultural producer and exporter, while Eurasia possesses abundant agricultural resources and growing markets. Together, these two blocs are key players in the global agricultural trade system. Despite recent significant growth in trade between these two regions, driven by factors like population growth and changing trade policies, there is still untapped potential for further cooperation.

This research uses network analysis to examine the agricultural trade relationships between the EAEU and ASEAN. The primary goal is to analyze the trade network and address key questions:

- Which countries play a central role in this network?
- How interdependent are the countries of these two regions in the agricultural sector?
- What are the main obstacles and opportunities for developing trade between the two blocs?

By analyzing various network metrics, this study aims to describe the network's features and topology, identifying common patterns in its evolution. The analysis is based on a balanced panel of 15 EAEU and ASEAN member countries in 2023, the most up-to-date data available. [1]

While traditional gravity models are often used to analyze bilateral trade, network analysis is more suitable for describing a complex, interconnected system. This study applies network analysis to identify key trade patterns. Following this introduction, Section 2 provides a literature review, Section 3 details the research design and data sources, Section 4 presents the empirical analysis, and Section 5 offers conclusions and research implications.

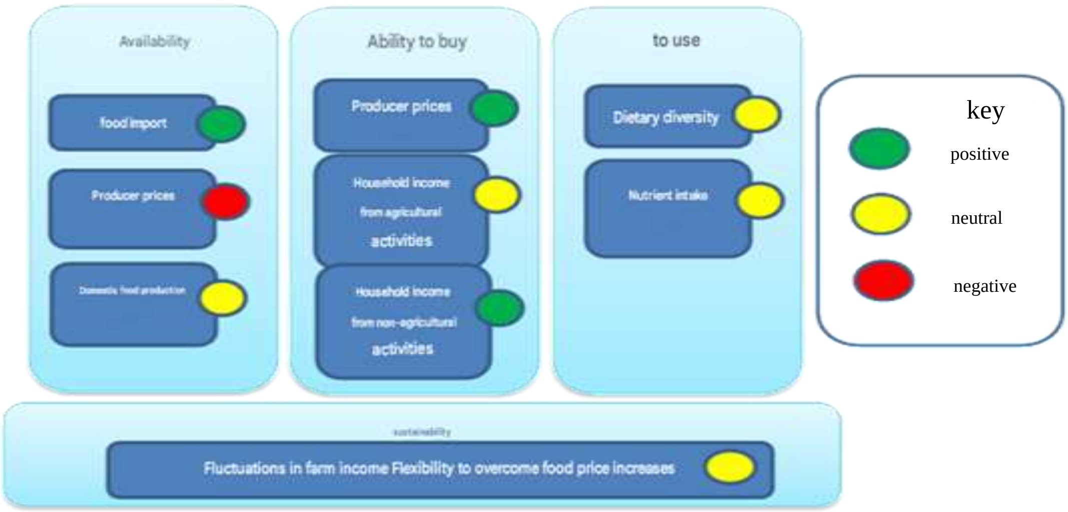

Fig. 1. How international trade affects four dimensions of food security in food-deficient countries
Source: Berkum, 2021

1. International data related to the trade of basic agricultural products between countries has been updated according to the reviewed sites until 2023, for this reason, this year has been reviewed as the most up-to-date year available.

Food security and trade are two fundamental and deeply interconnected aspects of modern society. Food security, defined as ensuring all people have access to adequate and nutritious food under both normal conditions and during crises, is a vital component of national development. While a country can work to be self-sufficient in food, in our modern economic world, one of the most important ways to achieve food security is by leveraging the capacities of other nations through trade. Trade plays a crucial role in balancing global food supply and demand. By enabling the import of goods, trade can cover domestic food shortages, balance surpluses and deficits in different regions, and reduce the impact of local shocks such as climate disasters. This helps to ensure a steady supply of food and contributes directly to the following four key dimensions of food security: Food Availability (covering domestic shortfalls), Food Access (increasing income and purchasing power), Food Use (providing a more diverse and nutritious diet), and Food Stability (making local markets less vulnerable to shocks). Trade can also boost the competitiveness of a country's agricultural sector by exposing small producers to international competition, which can drive innovation and efficiency (Brooks & Matthew, 2015). For low-income nations with food shortages, trade liberalization can be a powerful tool to enhance national food security (Martin & Laborde, 2018). It's important to recognize that while trade has many positive effects, its impact on the food system is not always straightforward. Trade's influence can be positive, negative, or neutral, depending on the specific segment of society being examined. For example, trade may benefit consumers by lowering prices and increasing choices, but it could also negatively affect small-scale domestic producers who struggle to compete with cheaper imports (Belaly, Vesna, & Berkum, 2021). Understanding these complex dynamics is key to developing policies that maximize the benefits of trade while mitigating its potential risks to food security.

An important aspect of international trade research in recent years has been the examination of trade networks and the position of countries within them. A network is a mathematical model using nodes (countries) and edges (trade relations) to describe the state of a system at a specific time (Wasserman & Fast, 1994). This approach has become increasingly popular among economists for studying global trade (Serrano & Begona, 2003). The use of this model to analyze trade in staple agricultural products is a new and important field of study.

As globalization deepens, economic relations between countries strengthen, creating a complex web of interdependence, competition, and influence (Lambin & Mayfroyd, 2011). In this environment, many countries have turned to global agricultural trade to compensate for their domestic supply gaps (McDonald et al., 2015). This has led to a significant increase in agricultural trade volume, which grew from $18.6 billion between 1961 and 1970 to $487.8 billion from 2009 to 2018 (World Bank, 2021). The trend is expected to continue as the world's population and dietary structures evolve, making agricultural trade networks more robust (FAO, 2021).

Analyzing global food security from a trade perspective is therefore crucial for discussions on sustainable development. Recent studies have focused on specific food types, such as cereals and soybeans, using quantitative measures of network characteristics like node strength, network density, and centrality to understand their evolution and develop evidence-based food security strategies.

The Agricultural Trade Network (ATN) has faced significant challenges in recent years due to rising trade tensions and global events like the COVID-19 pandemic (Bhanassi & Haiba, 2022). Major exporters like the United States have tightened export controls, while others like Russia and Ukraine have seen their participation in international markets hampered by conflict. Since 2020, export bans by key players like Kazakhstan, Russia, and Vietnam have further destabilized the global market (Adamczyk & Perez, 2020). The stability of the ATN is critical for global food security, especially for populous, rapidly growing economies.

Complex network analysis has emerged as a powerful tool for understanding these trade characteristics. The approach involves constructing networks where countries are nodes and trade flows are edges (Garlaschelli & Lafredo, 2009). This method has been applied to various sectors, including oil and natural gas (Zheng et al., 2014) as well as agriculture (Arita et al., 2022). For example, studies have shown that major producers like Brazil play a key role in meeting global food demand (Zhang et al., 2020). While existing research has provided valuable insights, there is a need for more comprehensive, network-wide studies that account for the multiple factors influencing agricultural trade, such as political risks, economic benefits, and geographical distance.

In the decade since its establishment, the Eurasian Economic Union (EAEU), which includes Armenia, Belarus, Kazakhstan, Kyrgyzstan, and Russia, has fostered strong economic ties within its bloc. Despite external shocks, internal trade has grown rapidly. However, the EAEU's trade relationships are now evolving to include a greater focus on bilateral trade and services with external partners, particularly with ASEAN Eurasian (Economic Commission Report, 2021).

The EAEU-ASEAN trade turnover was $17.7 billion in 2020, with EAEU exports at $6.6 billion and imports at $11.1 billion. The recent impact of Western sanctions on Russia has further increased the importance of this trade relationship. With much of Russia's typical trade with the EU halted, trade with ASEAN provides a logical alternative. Consequently, an agricultural trade network has emerged, with Russia as a key exporter of grains to the region.

Russia and Kazakhstan are the main agricultural players within the EAEU. In 2022, they collectively exported over 6 million tonnes of wheat, 1.2 million tonnes of barley, and around 900,000 tonnes of oilseeds (primarily sunflower and soybeans) to ASEAN. Corn exports also totaled about 300,000 tonnes. The largest importers of these goods in ASEAN were Vietnam, the Philippines, and Indonesia.

In the other direction, ASEAN's main agricultural exports to the EAEU are rice and palm oil. Thailand and Vietnam together exported about 500,000 tonnes of rice to Russia, while Indonesia and Malaysia supplied approximately 1.5 million tonnes of palm oil to the EAEU. These statistics highlight the diverse nature of agricultural trade between the two blocs, with each side leveraging its comparative advantages. However, it's important to note that these figures represent only a partial view of the total agricultural trade landscape. Eurasian (Economic Commission Report, 2021).

Table 1. Statistical comparison of some key indicators of ASEAN and Eurasia

agent	Asean	Eurasian Economic Union
population (million people)	651	183
Area (square kilometers)	4,522,518	20,229,248
Domestic GDP (trillion dollars, with the same purchasing power)	3	5
GDP per capita (dollars, with equal purchasing power)	4,600	27,000

Source: Trademap

ASEAN members have been aware of the implications of signing a free trade agreement with China for several years. Some ASEAN members (notably Singapore, Indonesia, Cambodia, and Thailand) are currently negotiating an FTA with the Eurasian Economic Union, while Malaysia and the Philippines have also expressed interest and are considering it.

Once these various FTAs with the Eurasian Economic Union are signed, it is clear that further changes and opportunities will arise in trade, especially in basic agricultural products.

And the common area of ASEAN and the EAEU will change significantly in terms of the development of supply chains, the availability of products, and the overall economic development of the two blocs.

Fig. 2. The geo– political map of the member countries of the ASEAN and Eurasian Economic Cooperation Union

The folliwng image illustrates how the two major economic blocs are trying to build stronger economic ties. It also shows that some ASEAN countries are seeking closer trade ties with the Eurasian Economic Union than others.In terms of traded goods, the following items can be checked:

Table 2. The top 10 goods imported by ASEAN from the Eurasian Economic Union (in thousands of US dollars)

rank	tariff code HS*	product	Value (thousands of dollars America)
1	27	mineral fuels, mineral oils and their distillation products; Bituminous	601,288
2	72	iron and steel	129,935
3	10	cereal	65,805
4	99	Unspecified goods elsewhere	60,737
5	31	Chemical fertilizers	58,146
6	76	Aluminum and its products	35,754
7	85	electrical machinery and equipment and their parts; Sound recorders and reproducers, TV...	35,754
8	87	Vehicles other than railway or tramway wagons and their parts and accessories	35,121
9	84	machinery, mechanical devices, nuclear reactors, boilers; Their parts	31,227
10	40	Rubber and its products	29,441

Source: Trademap

This table shows the top ten goods that ASEAN member states import from the Eurasian Economic Union. As can be seen, fossil fuels, metals, food, and machinery are among the major goods imported from the Eurasian Economic Union to ASEAN countries.

***Note:** The HS tariff code is an international system for classifying goods.

Table 3. top The 10 ASEAN export products to the Eurasian Economic Union (in thousands of US dollars)

rank	HS tariff code	product	Value (thousands of US dollars)
1	85	electrical machinery and equipment and their parts; Sound recorders and reproducers, television, nuclear reactors, boilers and parts thereof	2,377,690
2	84	Machinery, mechanical devices, nuclear reactors, boilers and their parts	669,208
3	15	animal or vegetable fats and oils and their cleavage products; prepared edible fats; Animal fats...	583,404
4	87	Vehicles other than railway or tramway wagons and their parts and accessories	446,962
5	64	shoes , gaiters and similar items; Parts of such goods	424,979
6	62	Garments and clothing accessories, not woven or crocheted	320,276
7	40	Rubber and its products	286,909
8	9	Coffee, tea, tea and spices	245,576
9	61	Garments and clothing accessories, knitted or crocheted	243,200
10	89	Ships, boats and floating structures	123,210

Source: Trademap

Table 3 shows the top ten goods that ASEAN member states export to the Eurasian Economic Union. As can be seen, electrical machinery and equipment, industrial machinery, food, and clothing are among the major exports from ASEAN to the Eurasian Economic Union.

Several factors, including trade policies, exchange rates, and domestic demand, influence the trade patterns between ASEAN and the Eurasian Economic Union. While the scope of trade is broad, with numerous goods flowing from ASEAN to Eurasian markets, foreign direct investment (FDI) has been relatively small.

Kazakhstan and Russia, the primary investors from the EAEU, have contributed a combined total of approximately $15.4 billion to ASEAN countries, with investments focused on the oil, gas, and tourism sectors. In contrast, ASEAN members—specifically Malaysia, Singapore, Thailand, and Vietnam—have invested about $9.3 billion in the EAEU, with a focus on agricultural products, food, and tobacco.

Currently, Vietnam is the only ASEAN member with a comprehensive free trade agreement with the EAEU, highlighting a key area for potential growth and further economic integration.

The role of corridors in international trade

Many countries and economic unions have placed corridors at the centre of their economic and territorial development strategies. Corridors play an important role in economic development, as economies need to be supported by efficient and sustainable logistics systems. They are often used as a development concept to create fast lines between points of origin and destination in different countries and as a concept to facilitate trade and transport and increase connectivity. Transport corridors can be defined from different perspectives, especially their physical and functional dimensions. A corridor is a set of space of a linear nature that connects large agglomerations (economic nodes) across a geographical area through a number of transport routes. (Healey, 2004)

Corridors reduce transportation costs, sustain rapid trade expansion, and facilitate integration within a country or region, transnationally, and into global markets. Figure 2 depicts the development trajectory of corridors.

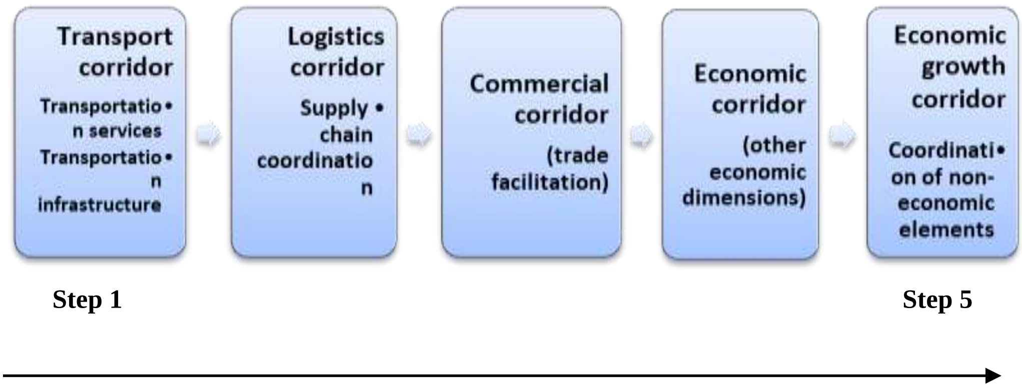

Fig. 3. Deve lopment path of corridors
Source: ADB, 2011c.

Five factors may contribute to the expansion of the role of the corridor phenomenon in trade flows.

First, the corridor is a "smart" tool for integrated territorial planning that combines interventions in infrastructure (and related services) with specific measures to strengthen key sectors. Second, economic corridor programs encompass a set of coordinated measures that ensure critical investment conditions with the ability to transform the territory.

Third, corridors inherently facilitate the creation of multi-stakeholder strategic alliances for development, involving local and central government authorities, private actors, and others.

The fourth factor is the symbiotic relationship between corridors and regional trade blocs, which often go hand in hand. According to Ernst and Young (2011), the combination of regional trade corridors and blocs helps to deepen country-based macro-analysis, enriching strategic thinking on how to stimulate inclusive and sustainable growth in the developing world. Finally, through years of trial and error, best practices in design and implementation have been identified that help improve the performance of new and ongoing corridor interventions.

As important factors in strengthening and developing trade, transport corridors and routes play a significant role in increasing agricultural trade between ASEAN and Eurasia. These infrastructures significantly enhance agricultural trade between the regions by reducing transportation costs, simplifying the movement of goods, and increasing productivity. By investing in the development of these infrastructures and creating appropriate supporting policies, it is possible to increase the volume of agricultural trade between the two regions and improve the livelihoods of communities.

For example, the International North-South Transport Corridor (INSTC) is one of the most important transport routes between Eurasia and Southeast Asia. Starting in Russia and running through Iran to India, the corridor could reduce transit times in these regions by up to 40 percent. The route is crucial for agricultural trade between Russia (a key member of the Eurasian Economic Union) and ASEAN members.

2. Literature review

Developing countries continue to face two major challenges in this domain. The first concerns food safety and access to regional and international markets. As noted by Worter (2015), developing economies often encounter significant market access constraints for raw materials. One example is the imposition of food safety restrictions. To overcome such barriers, exporters may adopt risk reduction measures and quality certification programs to improve their competitiveness in emerging overseas markets (Busby, 2003). However, balancing food trade with food safety objectives often necessitates government intervention and entails additional costs (Hansen & Jaffe, 2006).

In their study *Trade for Food Security: The Stability of Global Agricultural Trade Networks*, Wang et al. (2023) analyzed the evolution of the global agricultural trade network (ATN) from 1986 to 2018, estimating its grouping characteristics and network stability. They highlighted the emergence of the Euro-African community, the formation of three-pillar trade blocs, and the development of a multipolar community with a more complex structure. Although nodal stability in the global ATN has gradually increased over the decades, significant disparities remain across countries. For instance, the European Community achieved a stability score of 0.49, effectively securing its trade relations. Meanwhile, other leading communities demonstrated a steady upward trend in stability but still faced substantial challenges in sustaining trade relations. Thus, ensuring the resilience of trade networks and strengthening the global ATN against external shocks has become a central issue for maintaining global food security.

Similarly, Ibrahim et al. (2023), in their study *Food Security Implications for Sustainability: Do Trade Facilitation, Population Growth, and Institutional Quality Build or Undermine the Goal of SSA?*, examined the role of trade facilitation (TF) in shaping food security across 34 sub-Saharan African (SSA) countries between 2005 and 2019. Employing a two-stage generalized method of moments (GMM) estimator to address heterogeneity and endogeneity, they found that inefficient TF measures negatively affect food security in SSA. These adverse effects were evident in food availability, food access, and their composite index. Although the findings contradicted positive a priori expectations, they reflected the prevailing realities of SSA economies. Overall, the study concludes that the current TF regime undermines food security, largely due to heavy bureaucratic practices in importing and exporting staple foods. Population growth and institutional quality were also found to influence food security differently. The authors recommend reforming TF modalities to accelerate progress toward food security and sustainable development goals.

Yogiswari et al. (2023) investigated the relationship between imports and food security in 56 lower-middle-income countries during 2011–2016. Using the GMM approach, they reported that imports had an overall negative effect on food security. While imports increased food availability, they undermined food access, utilization, and stability, resulting in net negative effects. The authors suggest that including imports in food security frameworks can help ensure sustainable food supplies and compensate for domestic production shortfalls if accompanied by improved import regulations.

Karim et al. (2022) explored the implications of non-compliance with trade practices in African food exports. Their findings indicate that inefficient trade procedures and inconsistent food supplies exacerbate food insecurity on the continent, undermining both import and export performance. Similarly, Chen and Zhang (2022), in their study *Describing the Structural Transformation of Grain Trade Networks in the Belt and Road Regions: A Network Analysis Approach*, observed that grain trade within the Belt and Road Initiative (BRI) has created well-connected, complex trade networks. India, Russia, and Ukraine emerged as critical hubs, shaping the entire grain trade structure. Despite these advances, the networks exhibit a core–periphery structure with pronounced power asymmetries, leaving supply chains fragile and poorly resilient to shocks. The authors recommend strengthening regional cooperation, enhancing storage capacity, and restructuring networks to improve resilience and ensure food security in BRI countries.

Bahnassi and Haiba (2022), in *Implications of the Russia–Ukraine War for Global Food Security*, emphasized how global ATN stability has been undermined by escalating trade frictions, the COVID-19 pandemic, and geopolitical conflicts. Export controls imposed by the United States and disruptions in major exporters such as Russia and Ukraine have severely restricted participation in global markets.

Kris et al. (2021) developed a meta-population model linking human population growth, agricultural land use, and food production in interconnected regions (“patches”) through trade networks. Their findings underscore the importance of trade network topology in improving food security outcomes. Similarly, Berkum (2021), in *How Can Trade Create Inclusive and Sustainable Food System Outcomes in Low-Income Food-Deficit Countries?*, argued that trade can promote inclusive and sustainable food systems, but only when complemented by policies that diversify production and markets, enhance competitiveness, and improve farmers’ market access. The study highlights the necessity of collective international action to address food-related externalities, land use, and climate change.

Gupta et al. (2019), using a gravity model across 164 countries between 1985 and 2013, found that geopolitical risks negatively influence trade flows. Kantor and Cheng (2018) examined trade in environmental goods, showing that strict environmental regulations shape trade patterns, while innovation, geography, and financial uncertainty also play significant roles. Tsai and Song (2016) demonstrated that agricultural trade facilitates broader international trade by reinforcing national networks.

Earlier, Fetti, Scott, and Rockmore (2013) applied an extinction model from biology to study the robustness of global trade networks. Their findings suggest that while global trade networks are robust against random shocks, they are highly vulnerable to targeted disruptions. They further revealed a dual effect of increasing trade connections: such connections can absorb small shocks up to a threshold but can also amplify the impact of severe shocks by spreading them throughout the network.

Faustino and Litao (2010) studied trade flows between Portugal and the European Union (1996–2005) and found that foreign direct investment (FDI) and shared borders positively influenced bilateral trade. Market size, economic stability, and geographical distance also shaped trade outcomes. Masoomzadeh et al. (2021), analyzing Iran’s trade agreement with the Eurasian Economic Union (2001–2018), concluded that eliminating tariffs—particularly in industry and agriculture—would yield significant economic benefits for Iran.

Xiangtang et al. (2023), in *Trade for Food Security*, emphasized the evolution and stability of America–Asia and Europe–Africa agricultural trade communities, identifying four developmental stages of the global ATN. Similarly, Pan et al. (2023) studied the agricultural trade network of RCEP countries and highlighted spatial correlations, identifying Australia, China, Thailand, and Vietnam as central actors. Wang et al. (2019) further demonstrated that the global ATN has become increasingly diverse and multipolar, exhibiting both regional core–periphery dynamics and unbalanced growth at the national level.

Boglioni (2018) examined comparative advantages in the European Union, finding that specialization predicted under free trade was not observed in certain products, suggesting that free trade benefits may not always materialize uniformly. McBean et al. (2018), analyzing regional financial integration in East Asia and ASEAN, found that while integration progressed from 1998 to 2015, it was disrupted by the 2008 financial crisis.

Other studies have reinforced the link between productivity, proximity, and trade flows. Budinger and Breus (2008) showed that productivity positively influences exports among OECD countries, while trade declines with distance. Fagiolo, Reis, and Schiavo (2008), analyzing trade among 159 countries (1981–2001), introduced the concept of “vertex strength” to assess trade intensity. They found that while most countries maintained weak trade ties, the network displayed uneven structures, with stronger countries forming trade “clubs.” Despite globalization, the overall structure of the global trade network remained remarkably stable over time.

3. Data

This study adopts a network approach to examine trade flows between ASEAN and the Eurasian Economic Union (EAEU). Based on complex network theory, the agricultural trade network is represented as 'N = (P, E)', where *P* denotes the set of countries involved in agricultural trade, defined as *P = {P1, P2, … , P15}* (reflecting the 15 countries engaged in trade between ASEAN and the EAEU), and *E* represents the edges connecting nodes, i.e., trade relations between countries.

The trade network for key agricultural commodities—including wheat, barley, rice, corn, and oilseeds—was constructed using 'GFI software' for the year 2023, in line with the study’s modelling objectives. To the best of our knowledge, the application of network modelling in the context of trade and food security has not been previously undertaken, making this research an innovative and substantive contribution to the field.

In graph theory, the simplest type of network is a binary, undirected graph, where vertices (countries) are connected by edges without directionality. When the direction of flows is relevant—as in exports and imports—a directed network is applied. In the trade network, vertices represent countries, and edges denote their trade relationships. A directed graph is therefore appropriate when distinguishing between imports and exports, while an undirected graph may be used for aggregated flows.

This study examines several descriptive network statistics, including the number of edges, average degree, weighted average degree, network density, and average clustering coefficient. The **vertex degree** measures the number of trade partners each country has (Fagiolo et al., 2008). In directed graphs, degree is divided into 'in-degree' (imports) and 'out-degree' (exports). Edges may also be weighted, with weights reflecting trade values. The 'vertex strength' thus provides insight into the intensity of trade relations; a country with higher vertex strength engages in more substantial trade flows, whereas vertex degree merely reflects the number of trade partners regardless of trade volume (Fagiolo et al., 2008).

From these measures, the 'degree distribution function' can be derived. In a binary, unweighted network, this function represents the probability that a randomly chosen vertex has *k* edges (Fagiolo et al., 2010). In weighted networks, it captures the probability of a vertex having a weight equal to α. The shape of this distribution reveals structural properties of the network: for instance, undirected random networks typically follow a normal (bellshaped) distribution, whereas 'scale-free networks' exhibit right-skewed, power-law distributions, characterized by many nodes with few connections and a few highly connected hubs (Albert & Barabási, 2002).

The clustering coefficient is another network index. Using this index, it is possible to find out how much a country's trading partners are related to each other. For example, if we assume that Iran (i) has trade relations with k countries, these k countries can eventually have (k*k-1)/2 trade relations with each other and form a group or cluster. Now, if in the real world the number of trade relations between these countries is e, the clustering coefficient is obtained from equation 1:

$$C_j = \frac{e}{\binom{k}{2}} = \frac{2e}{k(k-1)} \qquad \text{(Equation-1)}$$

The average clustering coefficient is also equal to the average of all clustering coefficients of countries and is obtained from equation 2:

$$\bar{C} = (1/N)\sum_{i=1}^{n} C_1 \qquad \text{(Equation-2)}$$

In complex networks, it is sometimes important which vertex, actor, or individual is at the centre of the network. This centrality means having more connections with others. Centrality is divided into two types: local and global. Local centrality means a vertex that has extensive connections with its neighbors. Global centrality refers to a vertex that has strategic importance for the entire network. One of the criteria for measuring global centrality is the betweenness criterion. If P(kj) represents the number of shortest paths between k and j that pass through vertex i and P(kj) is the sum of the shortest paths between k and j, the global centrality criterion can be calculated from Equation 3 (Jackson, 2008):

$$Ce_i^B(g) = \sum_{k \neq j, i \notin \{k,j\}} \frac{p_i(k_j)/p(k_j)}{(n-1)(n-2)/2} \qquad \text{(Equation-3)}$$

Vertices with higher numbers are more central because they have more traffic compared to other vertices.

Another index used to examine centrality is the eigenvector index. The main objective of this index is to examine the importance of a country's neighbours in the trade network, and in fact, it examines the role of neighbours of countries with which it has trade relations; that is, countries with higher eigenvectors, which are considered central according to this index, have trade relations with countries that themselves have trade relations with numerous other countries (De Benedictis et al., 2013). This index is obtained by using the adjacency matrix and calculating the eigenvector.

Network measures are employed to provide deeper insight into the co-evolution of ASEAN–EAEU connectivity through agricultural trade. Given the complexity of trade and agricultural networks, a data-driven approach is applied to capture their dynamics and potential linkages. A set of network indicators is used to identify and characterize trade patterns of individual countries as well as their connectivity shaped by free trade agreements.

Network measures can be examined at different levels of regional aggregation. At the **local level**, analysis focuses on individual countries, corresponding to specific nodes or edges in network terminology. At the **intermediate level**, attention is directed to groups of nodes, capturing interactions within clusters of countries. At the **global level**, the structure and properties of the network as a whole are assessed (Eber et al., 2018; Mille et al., 2019; Morrison et al., 2022).

Connectivity can also be categorized according to the type of links between countries. **Direct connectivity** reflects bilateral trade relations between two countries. **Intermediate connectivity** captures second-order links, such as the trading partners of trading partners, and smaller subnetworks (e.g., triads). **Global connectivity** extends to higher-order linkages encompassing the broader network. Tables 4 and 5 present an overview of the network indicators applied in the analysis, corresponding to these varying levels and types of connectivity.

This research adopts a mixed-method descriptive–analytical approach, applying network analysis as a robust methodological tool to examine agricultural trade relations between ASEAN and Eurasia. Network analysis enables the study of complex relational structures among countries and provides a systematic framework for exploring connectivity patterns within trade systems.

Table 4. An overview of the network measures used in the analysis

Network measurement at different connectivity levels, regional aggregation	Local level	Middle level / society	Global level
local connection (direct connection)	Node degree, node strength	Classification indices, modularity of community diagnosis	Network density, network degree centrality (average node degree), network power centrality (average node power)
Average centrality (connection non direct)	Node degree/second order strength		The second-order centrality of the network (the average degree/second-order strength of the node)
Global centrality (indirect connection)	Node eigenvector		Network eigenvector (node eigenvector average)

Table 5. Description of the network indicators used in the analysis

Network measurement	Direction and weight	Level of accumulation	Network measurement
Connection/center actions			
Network density	Pointless ,weightless	global	It shows the ratio of real connections (links) to potential connections (links) and thus the probability of a link between both countries .
Node degree (first order and second order)	Directed , weightless	Local average and global	The degree of first-order connectivity shows the total number of trade links of a country and is identified based on binary network analysis . to export flows, indegree to flows Import refers . The second degree is defined as the sum of the first degree in all direct trading partners.
Node strength (rank first and second(	Directed, weighted	Local average and global	The first-order power indicates the total number of business links (per product and business partner) or the total business per node . Outstrength refers to export flows, instrength refers to import flows.
			The second-order power is defined as the sum of the first-order power of all direct business partners.
Special vector centrality	Directed , weightless/weighted	Local and global average	The connection of a node based on the connection of neighbors, neighbors of neighbors, etc., that is, the connection of a node is proportional to the sum of the connection indices of its neighbors.
Regional clustering measures			
Category	Unnecessary ,weightless / weighted	Regional / community level	Classification indices range from 1, which indicates that similar countries trade with each other (mixed network) to -1, which indicates the opposite (heterogeneous network).
Business clusters and modularity	Unnecessary ,weightless / weighted	Regional / community level	Trading clusters/communities are groups of countries that tend to trade more with each other than with countries outside the cluster/community.

Source: Geyik et al. (2021) and Jafari, Engman, and Zimmerman (2023)

The analysis applies unweighted network measures to capture the number of trade links per country. In network terminology, this measure corresponds to the **degree**, which reflects the number of non-negative trade flows associated with a country. Within the adjacency matrix, each cell takes the value of zero when no trade flow exists between two countries and one when a non-negative trade flow is present.

In addition to unweighted measures, results are also presented using two types of weighted measures. Trade links by country and product not only account for the presence of trade flows but also weight each link by the number of distinct products exchanged through it. When trade flows are considered in a single direction—either imports or exports—the structure is represented as a **directed network**. Conversely, in an **undirected network**, the direction of trade flows is disregarded. In such cases, the weight of the undirected network is typically calculated by summing exports and imports and dividing by two, i.e., ((exports + imports)/2).

Data collection methods

The dataset for this study comprises international agricultural trade flows between ASEAN and Eurasian countries. Data were obtained from reliable sources, namely the **World Trade Organization (WTO)** and the **Food and Agriculture Organization (FAOSTAT)**. The dataset includes annual bilateral export and import figures for the year 2023, covering five key agricultural products: wheat, barley, rice, oilseeds, and maize. A balanced panel of ASEAN and Eurasian member countries engaged in bilateral trade during 2023 was constructed for analysis. To ensure comparability of network measures over time, only countries consistently present in the 2023 dataset were considered. Sensitivity tests that included all countries available in each year produced comparable results. The year 2023 was selected as it represented the most recent period with complete data at the time of analysis. For greater reliability, both import and export data were utilized. All trade values are reported in U.S. dollars and adjusted for inflation using the U.S. Consumer Price Index (CPI).

Data analysis methods

Using this Gephi, a specialised network analysis software, is used to analyse the data software, various network indicators such as clustering coefficient, network diameter, and centrality can be calculated, and the network structure can be analysed. Also, statistical methods such as hypothesis testing and regression are used to examine the impact of various factors on business relationships.

4. Model estimation and results

In this study, the network for 2023[1] is examined. The trade network is shown in Figure 3.

As can be seen in Figure 4, the average degree, or the average number of trade relationships, is 40.667.

Figure 4 shows the Eurasian Economic Union and ASEAN agricultural commodity trade network. According to the available data and the shape of the network in 2023, Kazakhstan had the most trade relations and the greatest role in this area.

According to Table (6), the average clustering coefficient in this network also states that the countries that are export destinations of a particular country's goods have significant trade relations with each other; this shows that the agricultural commodity export network, considering its high clustering coefficient, can be a complex network type and is somehow intertwined.

1. International data on trade in basic agricultural products between countries has been updated according to the sites reviewed up to 2023, which is why this year has been reviewed as the most up-to-date year available.

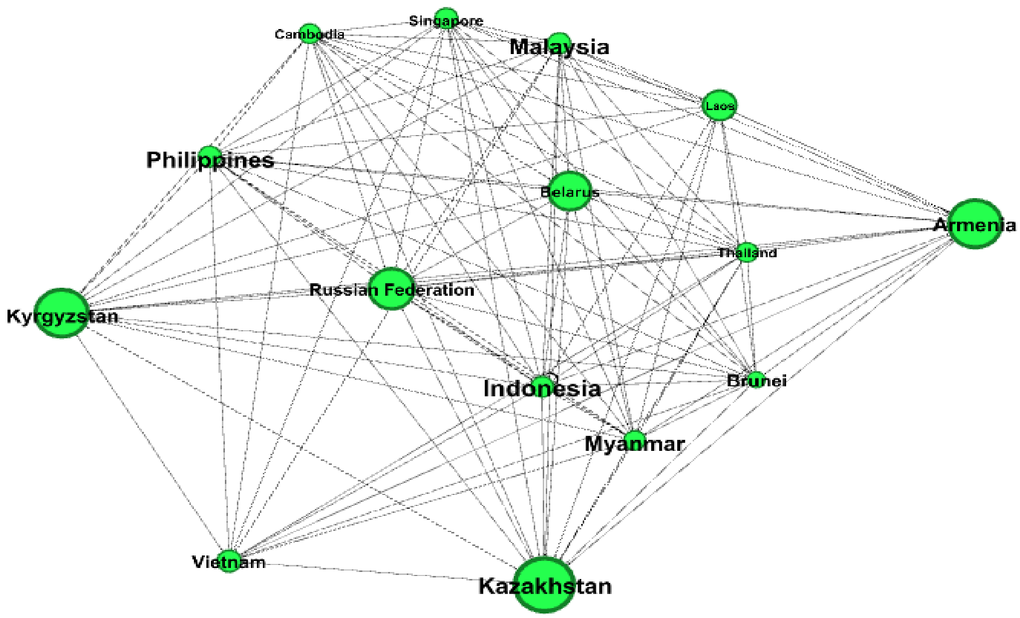

Fig. 4. Trade network of agricultural commodities between Eurasian and ASEAN member states in 2023
Source: research findings

Table 6. The 2023 size of the indicators of the trade network of basic agricultural products in

year	The number of ridges	middle grade	weighted average grade	Network density	Average clustering coefficient
2023	305	667/4	667/4	857/1	0.951

Source: research findings

Table 7. Calculated indices for ten member countries of ASEAN and five countries of the Eurasian Economic Union in the export and import network

Id Label	Degree	Weighted Degree	Eccentricity	Closeness Centrality	Harmonic Closeness Centrality	Betweenness Centrality	Clustering Coefficient	Number of triangles
Russian Federation	38	38.0	2.0	0.875	0.928571	0.0	1.0	66
Thailand	33	33.0	1.0	1.0	1.0	0.368535	0.945055	86
Singapore	34	34.0	1.0	1.0	1.0	0.309132	0.945055	86
Cambodia	33	33.0	1.0	1.0	1.0	0.368535	0.945055	86
Myanmar	46	46.0	1.0	1.0	1.0	0.761303	0.945055	86
Indonesia	50	50.0	1.0	1.0	1.0	0.523691	0.819048	86
Malaysia	48	48.0	1.0	1.0	1.0	0.523691	0.945055	86
Philippines	48	48.0	1.0	1.0	1.0	0.523691	0.945055	86
Brunei	40	40.0	1.0	1.0	1.0	0.509599	0.945055	86
Armenia	43	43.0	1.0	1.0	1.0	0.338098	0.945055	86
Kazakhstan	48	48.0	1.0	1.0	1.0	0.435628	0.945055	86
Kyrgyzstan	43	43.0	1.0	1.0	1.0	0.338098	0.945055	86
Belarus	36	36.0	2.0	0.875	0.928571	0.0	1.0	66
Vietnam	40	40.0	2.0	0.823529	0.892857	0.0	1.0	55
Laos	30	30.0	2.0	0.823529	0.892857	0.0	1.0	55

Source: research findings

Degree: Indicates the number of direct connections each country has with other countries.

Weighted degree: Similar to degree, but considering the weight of the connections (trade volume).

Externality: Indicates how far a node is from other nodes.

Betweenness centrality: Indicates the importance of a node in the shortest paths between other nodes.

Harmonic closeness centrality: Indicates how close a node is to all other nodes.

Betweenness centrality: Indicates how much a node plays a role in controlling the flow of information between other nodes.

Clustering coefficient: Indicates the degree to which neighbouring nodes of a node are connected.

Number of triangles: The number of groups of three nodes that are connected to each other.

Network analysis shows that Russia and Kazakhstan act as the main hubs of the wheat trade network in the region. ASEAN countries also play an important role in rice trade. Network clustering also shows that countries with similar climatic conditions tend to trade more with each other, and the main wheat trade routes are mainly through Russia and Kazakhstan to other countries.

5. Discussion and Findings

Contemporary international relations are characterized by extensive interdependence and interconnectedness, with trade representing one of the most significant forms of linkage. The expansion of cross-border economic relations has been accompanied by increasingly complex instruments of economic management. Fluctuations in exchange rates, alongside variables such as price levels and production capacity, directly influence exports, imports, and overall trade dynamics by shaping supply and demand. Globalisation, as a dynamic and multidimensional process, has accelerated international trade by eroding economic boundaries, fostering regional convergence, and promoting integration through international organizations. Prior to integration, states largely operated as separate economic systems; subsequent integration has generated larger economic blocs with reduced costs, greater resource allocation efficiency, increased production and exports, and enhanced food security.

Against this background, the present study examines the export and import network of basic agricultural products within the Eurasian Economic Union (EAEU) and ASEAN through the lens of complex network analysis. Bilateral trade data for 15 countries in 2023 were used to construct agricultural trade networks, and their structural properties were subsequently calculated. The results demonstrate that these networks follow a power-law distribution and display a high clustering coefficient, confirming their characteristics as complex systems. The analysis further highlights the central role of Kazakhstan, which functions as a pivotal hub within the EAEU network. Within ASEAN, Vietnam and Indonesia emerge as the most connected states, underscoring their importance in intra-regional trade. Russia and Kazakhstan also hold dominant positions within the EAEU due to their extensive trade linkages. By contrast, Brunei and Laos display limited connectivity, reflecting their marginal role in regional trade, while Thailand and Cambodia maintain modest levels of integration.

These findings are consistent with previous studies, including Fagiolo, Reis, and Schiavo (2008), which demonstrate that countries with extensive trade ties are often linked to states with relatively few partners. A positive correlation was also identified between vertex degree strength and clustering coefficients, suggesting that highly connected states are more likely to form cohesive trade clusters. The results also align with empirical evidence presented by Chen and Zhang (2022), Kris et al. (2021), and Berkum (2021), which indicate that trade growth contributes positively to food security. Diversifying trade partnerships, therefore, enhances resilience, reduces dependency on limited trade flows, and strengthens food security—an issue of particular relevance for Russia, which faces sanctions following the conflict in Ukraine. The creation of new trade corridors and the diversification of trade partners are thus vital for ensuring sustainable agricultural trade relations.

Empirical evidence on the evolution of agricultural commodity trade networks yields several further insights. First, geographic distance exerts a positive effect on the formation of trade linkages in 2023, contradicting the assumptions of the classical gravity model and underscoring the distinctive nature of agricultural trade. Second, significant border effects are observed, with states sharing land boundaries exhibiting stronger trade ties. Third, the level of economic development influences trade patterns, as agricultural trade tends to intensify between high-income and low-income economies. Fourth, differences in resource endowments are positively associated with trade networks, reflecting the continued importance of land availability and natural resources in food production. Finally, regional free trade agreements demonstrate a positive and significant effect, enhancing agricultural trade linkages across both blocs. Overall, the findings suggest that strengthening agricultural trade between ASEAN and the EAEU can foster economic growth, improve food security, and provide a replicable model of regional cooperation. Achieving these outcomes, however, requires sustained political commitment, coordination between public and private actors, and continued investment in infrastructure and innovation to ensure resilient and sustainable agricultural trade systems.

Policy proposals

Joint investment in the development and modernisation of ports, airports, and rail and road transport networks between the two regions is essential. Establishing special trade corridors for agricultural products with advanced warehousing and cold storage facilities can help reduce transportation costs and increase the quality of products along the way. Also, setting up smart and integrated logistics systems to track and manage the flow of agricultural goods can help increase efficiency and transparency in the supply chain.

Given the vulnerability of the agricultural sector to climate change and market fluctuations, it is essential to establish a joint early warning system to predict and manage food crises and establish joint strategic food reserves that can help control supply and demand fluctuations. Also, developing cross-border agricultural insurance mechanisms and launching a joint fund to support small farmers in the face of climate and economic shocks can help reduce risks and increase sustainability in agricultural production and trade.

To increase the volume and diversity of agricultural trade between the two regions, it is essential to establish a transparent and sustainable legal framework to support mutual investments in the agricultural sector. The establishment of a joint investment fund to support agricultural projects between the two regions could help attract more capital. Also, the establishment of online platforms to facilitate trade cooperation between agricultural companies in the two regions could help increase transparency and efficiency in trade.

Given the increasing demand for sustainable and organic agricultural products, common standards for the production of these products and the establishment of an integrated traceability and certification system should lead to increased added value of exported products and consumer confidence. In addition, supporting the implementation of sustainable agricultural practices through the provision of financial and technical incentives will help increase the sustainability of agricultural production and trade.

These policy proposals can help strengthen agricultural trade relations between ASEAN and Eurasia, enhance food security in both regions, and create new opportunities for economic growth and sustainable development in the world. Successful implementation of these policies requires close cooperation between governments, the private sector, and research institutions in international forums, especially in these two regions.

References

Albert, R., & Barabási, A. L. (2002). Statistical mechanics of complex networks. *Review of Modern Physics*, 74(1), 47–97.DOI: https://doi.org/10.1103/RevModPhys.74.47

Badinger, H., & Breuss, F. (2008). Trade and productivity: An industry perspective. Empirica, 35(3), 213–231.DOI: 10.1007/s10663-007-9058-8.

Baena-Rojas, J. J., & Herrero-Olarte, S. (2020). From Preferential Trade Arrangements to Free Trade Agreements: One of the Downturns of Cooperation in International Relations? *Social Sciences*, 9(8), 139. https://doi.org/10.3390/socsci9080139.

Behnassi, M., & El Haiba, M. (2022). Implications of the Russia–Ukraine war for global food security. *Nature Human Behaviour*, 6(6), 754–755. https://doi.org/10.1038/s41562-022-01357-6,

Berkum, S. (2021). How trade can drive inclusive and sustainable food system outcomes in food-deficit low-income countries. *Food Security*, 13(6), 1541–1554. https://doi.org/10.1007/s12571-021-01205-y.

Bilali, H. E., & Mpajb, B. (2021). *Agri-food markets, trade, and food and nutrition security*. In Elsevier eBooks. https://doi.org/10.1016/b978-0-12-820521-1.00004-6.

Boglioni, M. (2018). European economic integration: Comparative advantages and free trade of the means of production. Structural *Change and Economic Dynamics*, 51, 287–298. https://doi.org/10.1016/j.strueco.2019.09.003.

Brooks, J., & Matthews, A. (2015). Trade dimensions of food security (OECD Food, Agriculture and Fisheries Papers, No. 77). *OECD Publishing*. https://doi.org/10.1787/5js65xn790nv-en.

Brown, M. E., Hintermann, B., Higgins, N., Dorosh, P., & Fekadu, B. (2017). Do markets and trade help or hurt the global food system adapt to climate change? *Food Policy*, 68, 154–159. https://doi.org/10.1016/j.foodpol.2017.02.004.

Burkholz, R., & Schweitzer, F. (2019). International crop trade networks: The impact of shocks and cascades. *Environmental Research Letters*, 14(11), 114013. https://doi.org/10.1088/1748-9326/ab4f4a.

Chen, W., & Zhang, H. (2022). Characterizing the structural evolution of cereal trade networks in the Belt and Road regions: A network analysis approach. *Foods*, 11(10), 1468. https://doi.org/10.3390/foods11101468.

De Benedictis, et al. (2013). Network analysis of world trade using the BACI-CEPII dataset. *CEPII Working Paper*. https://doi.org/10.2139/ssrn.2364060.

Elahi, N., et al. (2021). Examining the effects of the trade agreement between Iran and the Eurasian Economic Union on the export sectors of industry and agriculture: An approach from the gravity model. *Scientific Quarterly of Economic Growth and Development Research*, 11(44), 105–120. https://doi.org/10.30473/egdr.2020.51845.5701. [in Persian].

Eurasian Economic Union. (2021). Promoting the development of trade cooperation between ASEAN and EAEU. Available at: https://eec.eaeunion.org/news/12-09-2021-1. (Accessed on: 2021, September 12).

European Union–ASEAN. (2024). *Agri-food trade statistical factsheet*. COMEXT-EUROSTAT database.

Fagiolo, G., Reyes, J., & Schiavo, S. (2008). On the topological properties of the world trade web: A weighted network analysis. *Physica A: Statistical Mechanics and its Applications*, 387 (15), 3868–3873. https://doi.org/10.1016/j.physa.2008.01.050.

Fry-McKibbin, R., Hsiao, C. Y. L., & Martin, V. L. (2018). Global and regional financial integration in East Asia and the ASEAN. *The North American Journal of Economics and Finance*, 46, 202–221. https://doi.org/10.1016/j.najef.2018.03.011.

Gupta, R., Gozgor, G., & Kaya, H. (2019). Effects of geopolitical risks on trade flows: Evidence from the gravity model. *Eurasian Economic Review*, 9, 515–530. https://doi.org/10.1007/s40822-018-0105-0.

Healey, P. (2004). The treatment of space and place in the new strategic spatial planning in Europe. *International Journal of Urban and Regional Research*, 28 (1), 45–67. https://doi.org/10.1111/j.0309-1317.2004.00502.x.

Ibrahim, R. L., Akinbobola, T. O., Bello, M. B., & Adeniji, O. (2023). The implications of food security on sustainability: Do trade facilitation, population growth, and institutional quality make or mar the target for SSA? *Sustainability*, 15(3), 2089. https://doi.org/10.3390/su15032089.

Jackson, M. O. (2008). *Social and economic networks*. Princeton University Press.

Jafari, Y., Engemann, H., & Zimmermann, A. (2023). Food trade and regional trade agreements – A network perspective. *Food Policy*, 119, 102393.https://doi.org/10.1016/j.foodpol.2023.102393.

Kareem, F. O., Martinez-Zarzoso, I., & Brümmer, B. (2022). What drives Africa's inability to comply with EU standards? Insights from the gravity model. *World Economy*, 45(10), 3141–3169. https://doi.org/10.1111/twec.13295.

Kathryn, R. F., Chris, T. B., & Anand, M. (2021). Implications of trade network structure and population dynamics for food security and equality. *bioRxiv*. https://doi.org/10.1101/2021.07.08.451671.

Tingting, Z., & Ju, Y. (2023). Factors influencing the global agricultural trade: A network analysis. *Agricultural Economics*, 69(5), 219–230. https://doi.org/10.17221/124/2023-AGRICECON.

United Nations ComTrade Database. (n.d.). Available at: https://comtradeplus.un.org.

Wang, X., et al. (2019). Trade network of global agricultural products weighted by physical and value quantity. *Economic Geography*, 39(2), 164–173. https://doi.org/10.15957/j.cnki.jjdl.2019.02.018.

Xiang, T. et al. (2023). Trade for food security: The stability of global agricultural trade networks. *Foods*, 12(2), 271. https://doi.org/10.3390/foods12020271.

Yogeeswari, S., Prakash, R., & Ramanathan, V. (2023). Imports and food security. *Global Journal of Emerging Market Economies*. https://doi.org/10.1177/09749101221146422.

Zichun, P. et al. (2022). Structural characteristics and influencing factors of agricultural trade spatial network: Evidence from RCEP 15 countries. *Ciencia Rural*, 52(5). https://doi.org/10.1590/0103-8478cr20230184.