

Global trade competition patterns in categorised meat products: A weighted network analysis

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Citation: Wang Q., Cheng R., Liu S., Xu W. (2026): Global trade competition patterns in categorised meat products: A weighted network analysis. *Agric. Econ. – Czech*, 72: 629–641.

Abstract: Meat trade plays a crucial role in global food systems and is a key area of competition among nations. This study analyses the competitive network of global categorised meat trade using weighted network analysis, focusing on four major meat types. The results indicate that meat trade competition is dominated by large consuming nations such as China, Japan, and Germany due to their high demand. Beef, pork, and poultry markets exhibit relatively concentrated competition among a small number of high-strength countries, whereas the sheep market is characterised by a more balanced competitive structure and greater variability in the strength-degree relationship. Weighted clustering coefficients decline as degree increases, particularly in the sheep market, indicating looser competitive groupings. The topological average nearest neighbour degree exhibits significant disassortativity across all four meat categories, whereas the weighted measure remains relatively stable, indicating the persistence of weighted assortative characteristics. Overall, the findings reveal pronounced structural heterogeneity in global meat import competition in 2022 and provide useful implications for product-specific trade strategies and risk management.

Keywords: competition strength; import competition; meat trade; structural heterogeneity

With the acceleration of globalisation and regionalisation, international trade has become a key driver in restructuring global supply chains and promoting national economic growth (Makki and Somwaru 2004; Hye et al. 2016; Abendin and Duan 2021). Within agricultural trade, meat products occupy a central position in the food supply chain and carry substantial economic, social, and environmental significance. The production and trade of meat products involve resource allocation, environmental costs, and consumer demand, and have become critical areas of competition among countries (Galloway et al. 2007; Guyomard et al. 2013; Caro et al. 2014; Rööß et al. 2014; Wen et al. 2018). In recent

years, the global meat trade market has become increasingly concentrated, with countries such as Brazil, Australia, and the United States relying on abundant natural resources and advanced agricultural technologies to lead global meat production and serve as major meat exporters (Szűcs and Vida 2017; Zdráhal et al. 2021; Sievert et al. 2022; Binotti and Bertolini 2023). Meanwhile, major consumer nations such as China and Japan are increasingly dependent on meat imports, engaging in intense competition in the international market (Sasaki et al. 2022; Wang 2022).

Against this background, existing studies have explored the issue of competition in meat trade from

Supported by the Humanities and Social Sciences Youth Fund of the Ministry of Education of China (23YJC790138) and the Fundamental Research Funds of Zhejiang Sci-Tech University (26096074-Y).

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multiple perspectives. First, some studies primarily employ econometric indices such as revealed comparative advantage, imported specialisation index, and relative trade advantage to measure and compare the competitive positions and evolutionary trends of exporting or importing countries in specific meat markets, thereby identifying the main market participants and the evolution of their competitive structure (Bojnec and Fertő 2014; Ramírez-López et al. 2020). Such studies are crucial for understanding the global pattern of meat trade, but their analytical focus is mainly on evaluating the competitive position of individual countries, with limited exploration of the formation mechanisms and structural characteristics of competitive relationships between nations. Second, other studies focus more on the impacts of policy, institutional, and environmental factors on meat trade. Research indicates that trade agreements, trade barriers, food safety regulations, environmental policies, and changes in market demand can significantly affect meat trade flows and exacerbate competitive disparities among nations (Johnson 2011; Teweldemedhin and Mbai 2013; Schierhorn et al. 2016; Poppy et al. 2019; Liao et al. 2024). While these studies help explain the determinants of meat trade patterns, they are primarily concerned with trade flows and their drivers rather than with the structure of competition among nations. Third, with the application of complex network theory to international trade research, scholars have increasingly adopted network analysis to characterise the structural features, influencing factors, and vulnerability points of meat and agricultural product trade networks (Chung et al. 2020; Hao et al. 2020; Zhang and Yang 2023). These studies have broadened understanding of the complexity of meat-related trade systems, but they mainly focus on trade connectivity, supply chain organisation, or general network evolution, with relatively limited attention has been paid to weighted competition structures across specific meat categories.

Overall, while existing meat trade research offers valuable insights from perspectives such as national competitiveness, policy-institutional factors, and network structures, two areas for further expansion remain. First, existing studies often analyse meat products at a relatively broad aggregate level or focus on only one specific meat category, making it difficult to systematically compare competitive structures across major meat types. Second, while network-based approaches have been applied, relatively little attention has been paid to weighted import competition structures, which capture not only whether countries are competitively

linked, but also how intensively they compete as reflected in trade values.

To address these gaps, this study employs a weighted network analysis framework to investigate global trade competition patterns in 2022 across four major meat categories: beef, sheep, pork, and poultry. By incorporating weighted network indicators, it reveals how competitive intensity, concentration, and structural characteristics differ across meat categories. The main contributions of this paper are threefold: (i) it extends the research by providing a comparative analysis of trade competition across categorised meat products rather than treating meat as an aggregate commodity or focusing on a single meat type; (ii) it applies weighted network indicators to capture both the structure and intensity of competition in global meat trade; and (iii) it derives differentiated policy implications for nations based on the competitive patterns observed within specific categories. Taken together, these contributions offer a more differentiated understanding of global meat trade competition and provide empirical support for more targeted trade and food security strategies.

Theoretical background and research hypotheses.

A comprehensive understanding of the competition patterns in global meat trade requires the integration of multiple theoretical perspectives, including traditional international trade theory, overlapping demand theory, and social network analysis.

The traditional international trade theory, rooted in Ricardo's theory of comparative advantage and the Heckscher–Ohlin (H–O) model, explains trade flows based on cross-country differences in productivity and factor endowments (Ricardo 1817; Ohlin 1933). These supply-side differences shape countries' production capacities and export specialisation, indirectly influencing import competition by determining the availability and cost structure of global supply. In meat markets, resource endowments and production technologies contribute to asymmetric supply conditions across countries, which in turn affect the intensity and direction of import competition among nations. Complementing supply-side explanations, the theory of overlapping demand highlights the role of demand similarity in shaping trade patterns, particularly for differentiated or consumption-driven products (Linder 1961). Countries with comparable income levels and dietary preferences are more likely to compete for similar imported meat products, intensifying import competition among large consuming economies and further shaping the structural characteristics of import competition networks. Social network theory provides

<https://doi.org/10.17221/266/2025-AGRICECON>

a structural framework for analysing patterns of interaction among actors (individuals, organisations, countries, etc.) based on relational ties rather than individual attributes (Wasserman and Faust 1994). In the context of trade, when multiple countries rely on similar import sources, they form competitive ties within a network structure. These networks not only shape the distribution of market influence but also reflect the strategic interactions among countries.

Taken together, these perspectives suggest that global meat import competition is jointly shaped by demand conditions, supply-side constraints, and the structural organisation of interactions among countries. More specifically, market size, demand similarity, sourcing overlap, and unequal market participation are expected to influence not only which countries occupy central positions, but also how competitive ties are distributed across product categories and network structures. On this basis, the following hypotheses are proposed.

H_1 : Under strong consumption-driven demand and high import dependence, countries with large domestic markets tend to occupy central positions in global multi-category meat import competition networks.

H_2 : Due to differences in production constraints, demand substitutability, and sourcing flexibility, import competition is expected to exhibit pronounced structural heterogeneity across meat categories, reflected in different patterns of concentration and differentiation.

H_3 : Broader engagement in competing import relationships is associated with higher competition strength, although the relationship between competitive breadth and competition intensity is expected to vary across meat categories depending on market balance and demand stability.

H_4 : Driven by similarities in import demand, overlap in sourcing markets, and substitution pressure, stronger competitive ties are more likely to be concentrated within locally interconnected groups in the global meat import competition network.

H_5 : Under stratified market participation and competitive hierarchy, stronger competitive relationships are more likely to be concentrated among importers occupying relatively similar competitive positions in the network.

MATERIAL AND METHODS

Data sources and description. The data used in this study are drawn from the UN Comtrade database (2024). To ensure data completeness, comparability, and timeliness across all meat categories, this study

focuses on global meat trade in 2022, which provides the most recent complete cross-sectional dataset available at the time of analysis. Notably, each node in the trade competition network represents a reporting entity as classified by the UN Comtrade database. The term 'country' in this study is used broadly to include both sovereign states and statistical territories or regions that are separately recorded in trade data. Based on the HS codes, meat is mainly classified into four categories: beef (HS codes 0201 and 0202), sheep (HS code 0204), pork (HS code 0203), and poultry (HS code 0207). In addition, the data were cleaned by removing unspecified regions, other regions, and cases where the importing country and the source country are the same. Following data preparation, competition strength was calculated using UCINET 6.645 (Analytic Technologies, USA), while MATLAB R2023b (MathWorks, USA) was employed to analyse and visualise other structural indicators of the competition networks.

Weighted network analysis indicators. To characterise competition patterns in global meat trade networks, this study employs several weighted network indicators that capture both the structure and intensity of trade relationships. Competition strength is first used to measure the overall intensity of competition faced by each importing country, reflecting the aggregate weight of its competitive relationships. Building on this, the cumulative distribution of competition strength is examined to assess whether import competition is concentrated among a small number of dominant countries or more evenly distributed across the network.

In addition, the relationship between trade connectivity and competition intensity is analysed to determine whether countries with broader competitive linkages also tend to exhibit higher competition strength. The local structural organisation of competition is further explored by incorporating clustering measures that account for trade intensity, thereby indicating whether stronger competitive ties tend to be concentrated within tightly connected local groups. Finally, neighbour-based indicators are employed to identify assortative or disassortative mixing patterns, shedding light on whether highly competitive countries tend to engage with similarly competitive partners or instead compete primarily with less-connected economies.

Detailed mathematical definitions and formulas for these indicators are provided in [Electronic Supplementary Material \(ESM\)](#).

Network construction. The purpose of this article is to explore the competitive pattern and characteristics of the global meat trade, which requires the

construction of a meat trade competition network. First, the identification of trade competition indicators is a prerequisite for network construction. Based on the widely used direct competition intensity indicator (Zhang et al. 2014; Dong et al. 2018; Wang et al. 2019; Kang et al. 2022), we adopt the direct competition intensity measure proposed by Glick and Rose (1999) as the weight of network edges to assess the competition level between two importing countries over meat resources from the same source country. This indicator captures import competition by jointly accounting for shared sourcing structures, relative import dependence, and the global importance of export markets, thereby providing an economically meaningful measure of competitive intensity among importing countries. The indicator is defined as follows:

$$S_{ij} = \sum_k \left\{ \left(\frac{Y_{ki} + Y_{kj}}{Y_t} \right) \times \left[1 - \frac{|(Y_{ki}/Y_i) - (Y_{kj}/Y_j)|}{(Y_{ki}/Y_i) + (Y_{kj}/Y_j)} \right] \times 100 \right\} \quad (1)$$

where: k – the exporting country supplying meat to both importing countries; Y_{ki} and Y_{kj} – the import values of meat from common country k to importing countries i and j , respectively; Y_t – the total global import value; Y_i and Y_j – the total import values of countries i and j , respectively.

Subsequently, an undirected weighted global meat competition network is constructed and expressed as:

$$G = (V, E, W) \quad (2)$$

where: $V = \{v_1, v_2, \dots, v_n\}$ – the set of nodes, and each element v_i denotes a country participating in the global

meat trade network; $E = \{e_{ij}\}$ – the set of edges, where $e_{ij} = 1$ if a competitive relationship exists between nodes v_i and v_j , and $e_{ij} = 0$ otherwise; $W = \{w_{ij}\}$ – the edge weights in the network, which indicate the direct competition intensity between countries.

RESULTS

Node strength characteristics. Table 1 reports the top ten countries or regions ranked by competition strength across different meat categories, showing clear heterogeneity in global meat import competition in 2022.

Overall, the beef and sheep markets exhibit relatively similar competition structures, with high competition strength concentrated in major importing economies in Asia, such as China, Japan, and the Republic of Korea, as well as developed countries in Europe and North America. This pattern suggests that import competition in ruminant meat markets is primarily driven by a limited number of high-demand countries with strong and relatively stable consumption needs.

By contrast, pork and poultry markets exhibit more diversified competitive structures. In addition to major importing countries such as China, Japan, and Germany, a larger number of emerging economies, including Mexico, Romania, the Philippines, and Angola, also rank among the most competitive importers. This reflects the growing role of emerging economies in the global competition network, driven by rising demand, stronger consumption power, and relatively flexible sourcing strategies.

Notably, China, Germany, and Japan rank among the strongest competitors across multiple meat categories. China ranks first in all four major meat categories,

Table 1. The top 10 countries (regions) ranked by strength (Str.) in trade competition networks

Beef		Sheep		Pork		Poultry	
Country/Region	Str.	Country/Region	Str.	Country/Region	Str.	Country/Region	Str.
China	668.88	China	875.33	China	365.05	China	431.36
Republic of Korea	172.91	United States	724.80	Japan	306.12	Mexico	225.30
United States	158.28	United Kingdom	197.45	Italy	260.86	Germany	194.96
Japan	145.72	Germany	172.59	Republic of Korea	198.95	Japan	181.28
Italy	108.03	Malaysia	171.99	Poland	183.82	United Arab Emirates	173.66
Germany	106.48	Canada	171.79	Mexico	169.59	United Kingdom	171.81
Netherlands	97.18	Japan	151.84	Germany	135.84	France	152.04
France	74.52	Republic of Korea	137.76	United Kingdom	123.08	Netherlands	127.55
Hong Kong SAR, China	67.24	France	135.14	Romania	116.20	Philippines	95.57
Canada	65.45	Netherlands	128.60	Czechia	110.49	Angola	84.27

Source: Authors' own elaboration

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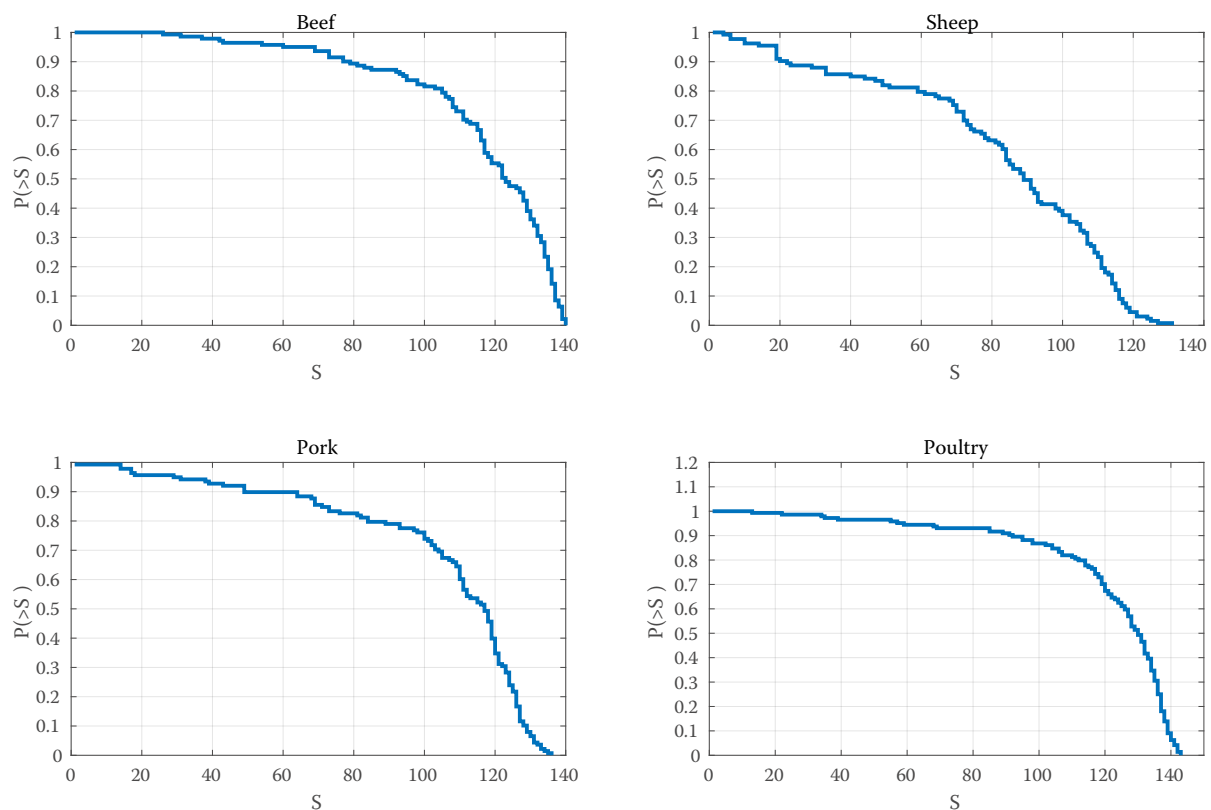


Figure 1. Cumulative strength distribution of categorised meat

$P(>S)$ – the cumulative probability that the competition strength is greater than S ; S – the competition strength

Source: Authors' own elaboration

highlighting how large domestic markets and sustained import demand are associated with central positions in global meat import competition, as expected in H_1 . This also indicates that countries with large and persistent consumption needs are more likely to become systemically important competitors across multiple meat markets.

Cumulative strength distribution characteristics. The degree (strength) distribution of real-world networks has different distributional characteristics (Amaral et al. 2000; Boccaletti et al. 2006; Guimerà et al. 2007). Figure 1 shows clear differences in the distribution of competition strength across meat categories in 2022, indicating substantial heterogeneity in competitive structures.

Specifically, beef and pork markets exhibit relatively gradual declines in the low-strength region, followed by sharp drops in the high-strength region. This pattern indicates that while many countries exhibit comparable levels of competitive strength, import competition is ultimately dominated by a small number of highly competitive countries that exert disproportionate influence on market outcomes.

Economically, this suggests that competition in beef and pork trade is concentrated around a limited number of major importers, whose demand scale gives them greater influence over the overall structure of market competition.

Compared to beef and pork, poultry shows a flatter trend in the low-strength region, followed by a steep drop in the high-strength region. This distribution suggests that many countries globally have relatively balanced competitive strength in poultry trade, while the steep decline indicates that only a few countries possess extremely high competitive power. This points to a market structure in which broad participation coexists with the continued dominance of a few leading competitors.

By contrast, the cumulative strength distribution of sheep declines more evenly than those of beef, pork, and poultry. This indicates that competition strength is distributed more evenly across countries, reflecting a more balanced and less concentrated competitive environment in the sheep market. This weaker concentration suggests that sheep trade is less dominated

by a very small number of importers than the other meat categories.

The contrast between the more concentrated beef, pork and poultry markets and the more balanced sheep market suggests that import competition is organised differently across meat categories, consistent with H_2 . More broadly, these cross-category differences indicate that meat import competition cannot be understood as a single uniform structure, but instead varies systematically across product markets.

Strength-degree correlation characteristics. Figure 2 illustrates the results of the strength-degree correlation analysis for the competitive network of categorised meat trade in 2022. Across all meat categories, competition strength tends to increase with degree in the high-degree region, indicating that countries facing more competitors are generally exposed to higher competitive pressure.

For beef, pork and poultry markets, strength increases sharply with degree beyond a certain threshold, suggesting the presence of dominant countries that combine extensive trade connections with high trade

intensity. Economically, this indicates that competition in these markets is concentrated among a limited number of countries that are both deeply embedded in the market and subject to strong import competition.

In the sheep market, although there are high-strength nodes in the high-degree region, these nodes are more scattered, with considerable fluctuations and no clear upward trend. This suggests that the link between competitive breadth and competition intensity is less stable in sheep trade, reflecting a more balanced market structure. This weaker regularity implies that having more competitors does not necessarily translate into proportionately stronger competition in sheep imports, possibly because market demand and sourcing structures are less concentrated.

Across all meat categories, countries facing a broader set of competitors generally tend to experience stronger competition intensity, although this relationship is much more pronounced in beef, pork and poultry than in sheep, which is consistent with H_3 .

Weighted clustering characteristics. Figure 3 compares the topological clustering coefficient $C(k)$ and the

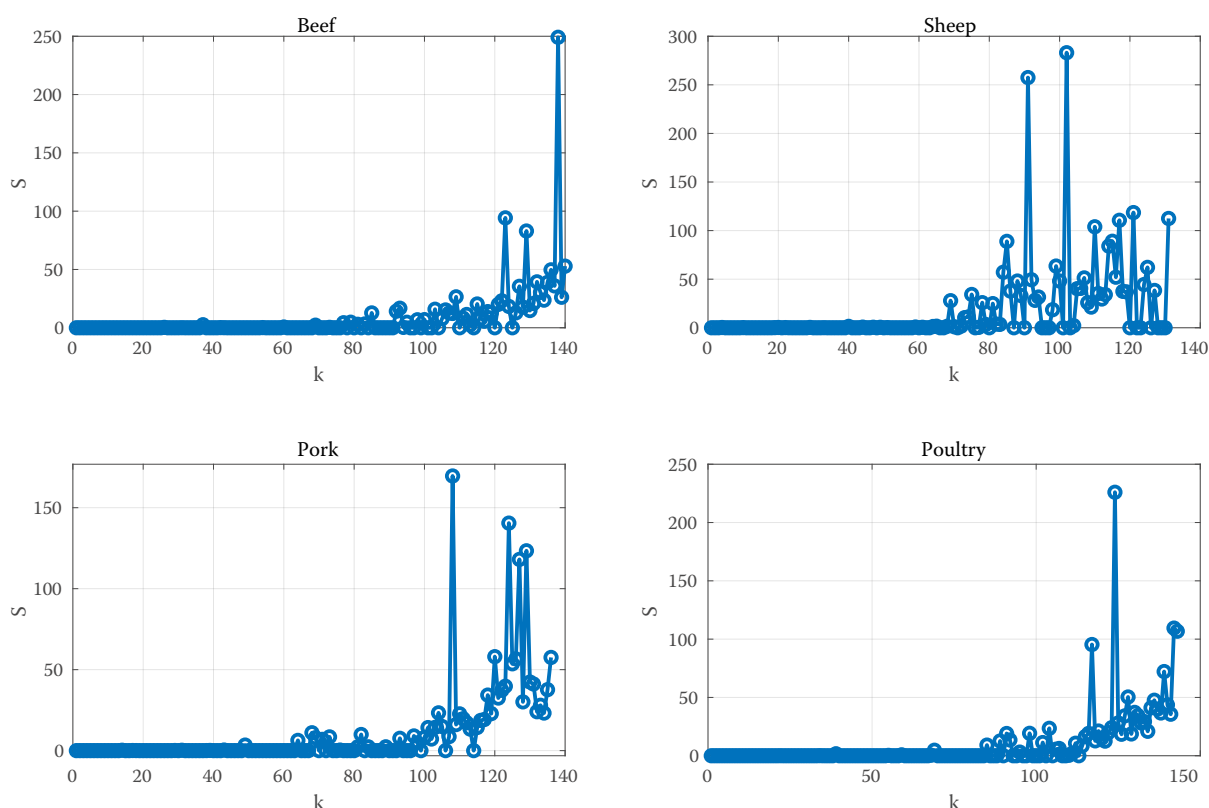


Figure 2. Strength-degree correlation of categorised meat

k – the degree of a node; S – the competition strength of a node

Source: Authors' own elaboration

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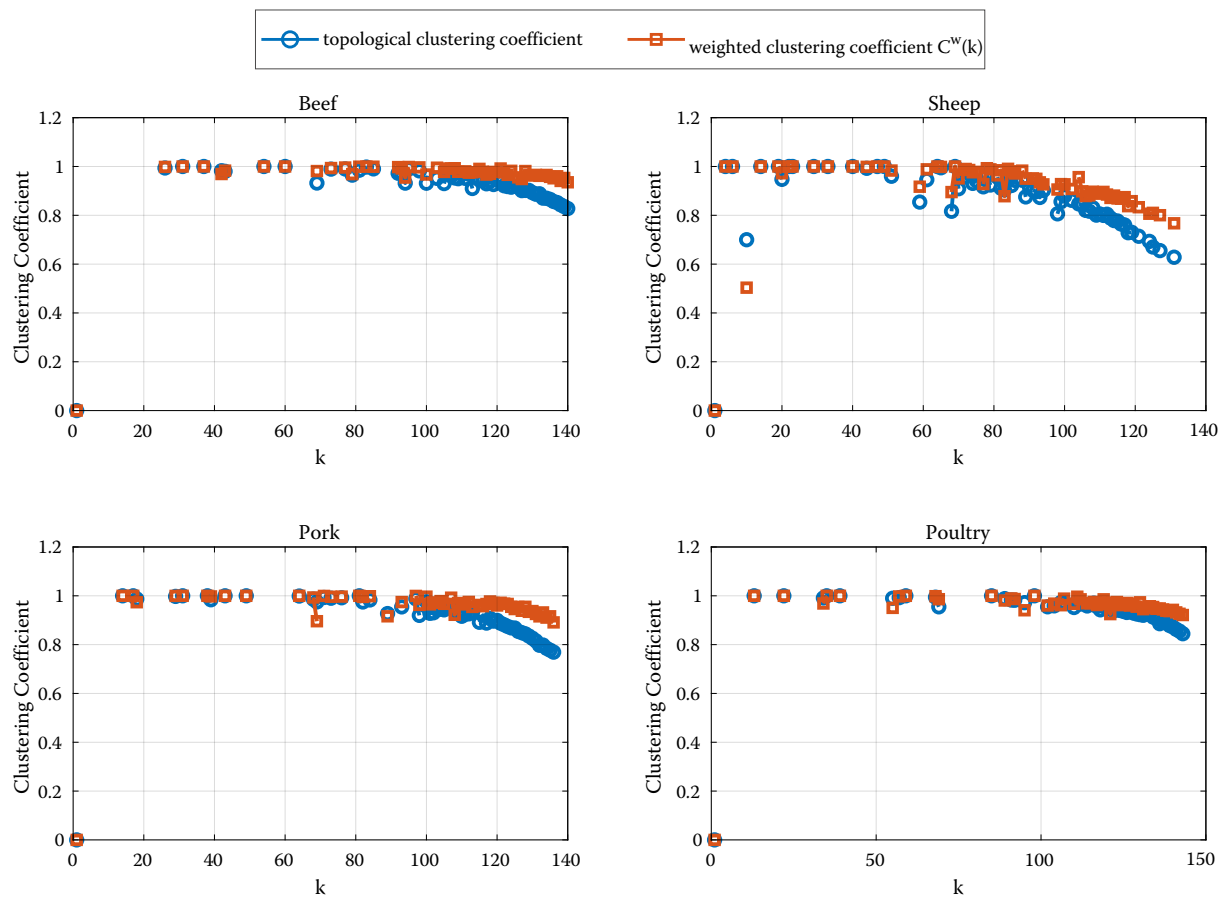


Figure 3. Clustering coefficient $C(k)$ of categorised meat

k – the degree of a node

Source: Authors' own elaboration

weighted clustering coefficient $C^w(k)$ in 2022. Across all four meat markets, the clustering coefficients of low-degree nodes remain very close to 1, suggesting that countries with relatively few competitors are typically embedded in highly closed competitive triplets. As degree increases, both the topological and weighted clustering coefficients decline, indicating that local cohesiveness weakens as the number of a country's competitors increases. This means that competition becomes less tightly grouped as countries expand the range of their competitive relationships.

At the same time, the pattern of $C^w(k) > C(k)$ is particularly evident among high-degree nodes, implying that high degree interconnected triplets are more likely formed by edges with large weights (Barrat et al. 2004; Barthélemy et al. 2005; Costa et al. 2007). This highlights that strong competition tends to be embedded within clusters of importers competing over similar market opportunities, rather

than being evenly dispersed throughout the network. These patterns suggest that countries with stronger competitive linkages are more likely to cluster within locally interconnected groups in the global meat import competition network, consistent with H_4 . Economically, this implies that intense rivalry is more likely to be sustained within groups of importers facing overlapping competitive pressures, rather than across isolated bilateral relationships.

Cross-category differences are particularly obvious in the sheep market, where weighted clustering declines most rapidly at high degrees, suggesting relatively loose competition structures when countries face many competitors. In contrast, the poultry market exhibits the smallest gap between weighted and unweighted clustering coefficients in high-degree regions, indicating that competitive concentration in poultry trade is less dependent on trade intensity and that competition structures remain relatively stable.

Weighted assortative characteristics. In both unweighted and weighted networks, assortativity and disassortativity can be used to explain the distribution characteristics of average nearest neighbour degrees, revealing the connection preferences of nodes within the network structure (Newman 2002, 2003; Barrat et al. 2004; Xu and Harriss 2008). Figure 4 compares the unweighted (topological) nearest neighbour degree k_{nn} and the weighted nearest neighbour degree k_{nn}^w in 2022. When $k_{nn}^w > k_{nn}$, edges with larger weights tend to be associated with neighbours of higher degrees. Conversely, if $k_{nn}^w < k_{nn}$, stronger ties tend to connect to less-connected neighbours.

From Figure 4, it can be observed that in the low-degree region for the four meat markets, k_{nn}^w and k_{nn} exhibit considerable dispersion, suggesting a diversity of competitive relationships. This indicates that less-connected countries do not follow a uniform competitive pattern, but instead engage with different types of rivals depending on the structure of each

market. In the high-degree region, the k_{nn} of the four types of meat markets declines as degree increases, which indicates the major competitors tend to connect with the countries of lower degree, reflecting the disassortative characteristic of the network structure in the meat competition network.

However, k_{nn}^w remains relatively high and exhibits smoother trends across meat categories. This indicates that although highly competitive countries may be topologically connected to less-connected partners, stronger competitive ties tend to be associated with neighbours of higher degree. Therefore, compared with the unweighted network, the weighted network exhibits a stronger assortative tendency. In economic terms, this means that the most intense competition is not evenly spread across all relationships, but is more likely to be concentrated among countries occupying relatively important positions in the market, supporting the expectation in H_5 . This pattern points to a stratified competitive structure in which stronger

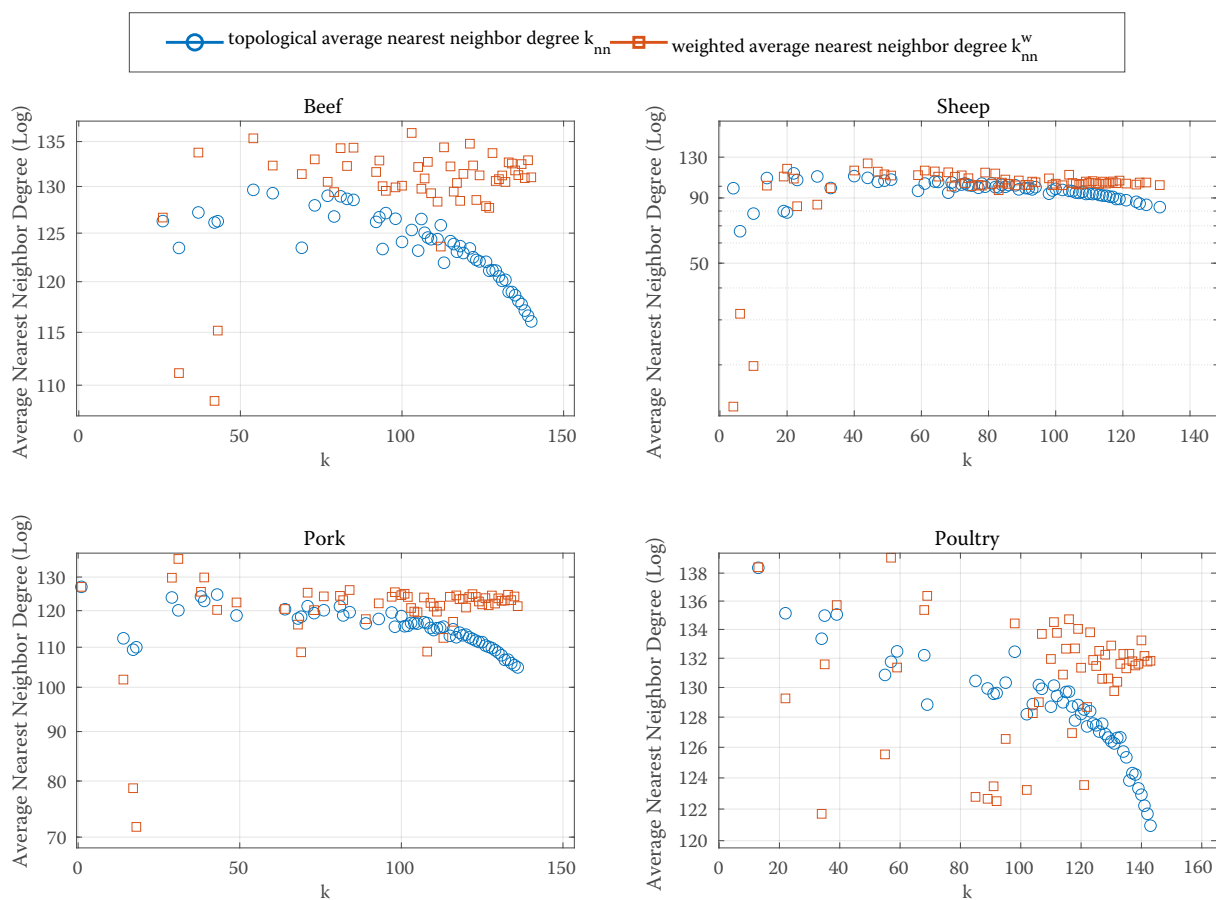


Figure 4. Average nearest neighbour degree of categorised meat

Source: Authors' own elaboration

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competition is more likely to emerge among relatively influential importers.

The sheep market displays weaker disassortative tendencies and lower fluctuations in weighted assortativity, suggesting a more stable and balanced competitive structure with less pronounced dominance among major competitors. This again points to a less hierarchical competitive environment in sheep trade than in the other meat categories. Compared with beef, pork, and poultry, competition in sheep trade therefore appears not only less concentrated, but also less strongly organised around a clear competitive hierarchy.

DISCUSSION

The application of complex network theory in international trade analysis provides an effective complement to traditional economic methodologies, particularly in revealing structural features of trade systems that are difficult to capture using national-level indicators alone (Cai and Song 2016). Recent studies further suggest that the competition and vulnerability of agri-food trade systems depend not only on trade volumes, but also on network interdependence, connectivity, and structural concentration (Jafari et al. 2024; Wang et al. 2025). Building upon this foundation, weighted network analysis offers a more detailed examination of trade competition by comprehensively considering both network structure and trade intensity, thereby illuminating the heterogeneous competitive landscape among different meat product categories.

The strength centrality results indicate that import competition within the global meat market is predominantly concentrated among major consuming economies. China's dominant position across beef, sheep, pork, and poultry markets reflects its large and persistent domestic demand and strong dependence on meat imports, which intensifies competitive interactions with other importing countries (Qiang et al. 2020). Additionally, substantial cross-category differences emerge. For example, the United States shows high competition strength in the beef and sheep markets, but does not rank in the top ten for pork and poultry, reflecting category-specific competitive advantages that may be related to its production capacity, market demand, cost advantages, and trade policies (Mutondo and Henneberry 2007; Sande and Houston 2007; Hejazi et al. 2019). More broadly, these findings indicate that centrality in meat import competition is category-specific rather than remaining consistent across all products, and that large economies do not necessarily

occupy similar competitive positions in every meat market. The core positions of importing countries vary substantially depending on whether network importance is assessed in topological or weighted terms, highlighting the importance of distinguishing market size from actual competitive influence (Wang et al. 2025). Overall, meat trade competition tends to concentrate in major meat-consuming nations, but the implications of this concentration differ markedly across categories.

The cumulative strength distribution highlights the significant heterogeneity in the competitive structures across different meat categories. The beef, pork, and poultry markets exhibit highly concentrated competitive patterns, with a small number of countries exerting disproportionate influence on import dynamics. Such distributions dominated by leading nodes are also common in global food and agricultural trade networks and are often associated with greater systemic vulnerability (Grassia et al. 2022; Xu et al. 2024). In highly vulnerable meat trade systems, such concentration implies that sourcing adjustments or demand shocks by a few dominant importing countries may trigger broader ripple effects across the entire network, especially when multiple countries compete for similar suppliers. In contrast, the competitive structure of the sheep meat market is more evenly distributed, with relatively homogeneous competitive strength across countries. This difference may be related to the fact that sheep meat consumption is more strongly shaped by regional and cultural preferences, resulting in a more dispersed demand pattern, while its production depends more heavily on grassland resources, grazing systems, and breeding management conditions, making supply expansion relatively inelastic and thus less conducive to the formation of a highly concentrated competitive structure dominated by a few major importers (Montossi et al. 2013; Martin et al. 2024).

The correlation between node strength and degree reveals distinct connectivity patterns in each meat market. Across the four major meat markets, broader participation in import competition is generally associated with stronger competition intensity, indicating that an expansion in the scope of competition is often accompanied by higher cumulative competitive pressure. However, in the sheep market, while there is some positive correlation between node strength and degree, the variability is greater. In other words, broader competitive exposure does not always translate proportionally into stronger competition intensity. Competitive relationships in the sheep meat market are more likely to be affected by exogenous factors such

as trade policies, supply constraints, and demand fluctuations, resulting in greater dispersion in competition intensity among highly connected countries and a relatively more unstable and less predictable competitive environment (Urak and Bilgic 2023).

The clustering analysis likewise reveals both similarities and differences in the structure of the categorised meat networks. As the number of competitors increases, the cohesion among competing countries generally declines, indicating that intensified competition weakens the formation of tightly interconnected competitive groups. This tendency is most pronounced in the sheep market, where competitors do not form dense competitive clusters, reflecting a relatively decentralised structure. By contrast, the poultry market exhibits a relatively more stable clustering pattern, suggesting that even as competitive exposure expands, local competitive groups maintain relatively high cohesion and strong competitive ties remain embedded in existing closed structures. This feature may be related to the shorter production cycle of poultry, greater flexibility in supply adjustment, and its relative advantage as a substitute in certain meat consumption patterns (OECD/FAO 2025).

Assortativity analysis provides additional insights into competitive behaviours across various meat markets. From a topological perspective, the global meat import competition network largely exhibits a core–periphery pattern of connections, and similar disassortative structures have also been observed in other trade network studies (Gutiérrez-Moya et al. 2023). Although core importing countries maintain extensive competitive ties with countries at different levels, once the strength of competitive relationships is incorporated, high-intensity competition tends to occur more frequently between countries with similar competitive positions and comparable levels of market participation, shaped by the stratification of market participation and the hierarchy of competitive structure. This pattern is especially obvious in the pork and poultry markets, where major competitors maintain tight economic ties through high-intensity trade. In contrast, the more balanced and stable competitive relationships observed in the sheep market may be explained by the fact that participants are relatively similar in their competitive positions and that no clearly dominant competitor exists.

CONCLUSION

This research constructs a cross-sectional global import competition network for categorised meat based

on 2022 trade data. Utilising five key network indicators, it systematically analyses the structural characteristics of competition across countries and product categories. Focusing on beef, pork, poultry, and sheep meat, the analysis reveals substantial heterogeneity in competition structures, highlighting that global meat trade competition is shaped by both product-specific characteristics and network-based interactions among importing countries.

The results show that competition in beef and pork markets is highly concentrated, with a small number of major importing countries occupying dominant positions and exerting significant influence on market structure. In contrast, the sheep meat market exhibits a more dispersed and relatively balanced competition structure, while poultry trade displays relatively stable competition patterns supported by established trade linkages. These findings indicate that competitive dynamics differ markedly across meat categories and cannot be adequately captured by uniform analytical or policy approaches.

These structural differences carry important policy implications. First, in the highly concentrated beef and pork markets, core countries face greater competitive pressure and potential systemic risks, which become particularly prominent when global supply chains are exposed to external shocks. Countries with high strength centrality or strong exposure to dense competitive structures are more likely to absorb and transmit competition through overlapping sourcing markets. Therefore, policy in these markets should focus less on diversification in a purely numerical sense and more on reducing dependence on highly contested suppliers and expanding access to structurally distinct sourcing channels. Such measures are crucial for enhancing supply-chain resilience and mitigating market vulnerability. Second, in the sheep market, the relatively even distribution of node strength and the low competitive concentration result in a more decentralised competition structure. This provides greater flexibility in trade partner selection and sourcing strategies, especially for peripheral countries. Under this relatively dispersed pattern, policy should place greater emphasis on market intelligence, bilateral relationship management, and the identification of stable niche suppliers, rather than relying mainly on broad diversification strategies. Finally, in poultry trade, strong competitive relationships are largely sustained by established trade connections. Together with the relatively stable clustering pattern, this suggests that poultry competition is more likely to intensify within

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locally interconnected groups sharing similar sourcing channels. Accordingly, countries embedded in such clusters need not only stable trade ties, but also greater sourcing flexibility across alternative supplier groups to reduce persistent competitive overlap.

Overall, the findings suggest that competition management and trade policy design should be product-specific rather than uniform across meat categories. Tailoring strategies to the distinct structural characteristics of individual meat markets is crucial for enhancing global market participation and effective risk management. At the same time, it should be noted that this study adopts a cross-sectional network perspective based on 2022 trade data. Although 2022 provides a meaningful post-pandemic snapshot of global meat import competition under relatively complete and comparable trade conditions, it still limits the ability to capture dynamic changes in competition patterns and does not allow for causal interpretation. Therefore, the observed structures should be understood as a contemporaneous picture of global meat import competition rather than as evidence of longer-term stability. Future research could extend the analysis to multi-year or dynamic network frameworks to examine how the roles of individual countries evolve across meat markets and to assess the impacts of external shocks, such as global pandemics or environmental policies, on competition dynamics in global meat trade.

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Received: June 24, 2025

Accepted: June 4, 2026

Published on-line: September 29, 2026