Analysis on Influencing Factors of Trade Network Evolution Between China and ASEAN Countries

Haining Zhang*

Xinjiang University, Xinjiang, 830000, China

*Corresponding author's email: 1401070528@qq.com

Abstract. Based on the intermediate goods trade data between China and the ten ASEAN countries from 2001 to 2022, this paper explores the structural evolution characteristics of the China-ASEAN intermediate goods trade network. The study finds that the network has transformed from a "unipolar core-periphery" model to a "multipolar interdependence-hub symbiosis" model, with increased network density, shortened average distance, and a fluctuating downward trend in the symmetry index affected by external shocks. The pattern of national network centrality has been restructured: China's core advantages have narrowed, while multiple ASEAN countries have achieved comprehensive improvement in multi-dimensional centrality, becoming key hubs in the regional value chain.

Keywords: China-ASEAN; Intermediate Goods Trade Network; Social Network Analysis.

1 Introduction

Since the 21st century, economic and trade cooperation between China and ASEAN has continued to deepen, with both sides becoming core trading partners for each other. They have jointly established a free trade area covering the largest population and possessing the most significant development potential globally, gradually forming a regional industrial chain and supply chain network characterized by refined division of labor, close linkages, and efficient coordination. As the core carrier of cross-border production network division and collaboration, intermediate goods trade dominates the cross-border flow of technology, capital, and value-added. It serves as a key indicator of deep integration of regional value chains and the integration of production networks, laying a solid foundation for regional economic integration and shared prosperity. It has also become an important engine driving the steady growth of the Asia-Pacific and even the global economy. In April 2025, the Central Conference on Neighborhood Diplomacy explicitly proposed to build a community with a shared future with neighboring countries, deepen regional development integration, create a high-level connectivity network, and strengthen collaboration in industrial and supply chains. At the same time, the global rise of unilateralism and trade protectionism, coupled with external uncertainties arising from the restructuring of international economic and trade rules, has

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prompted countries to accelerate the diversification and regionalization of supply chains, further enhancing the coordination and synergy between China and ASEAN's industrial and supply chains (Zhang, 2021)[1]. Against this complex and realistic background, systematically analyzing the structural positioning, dynamic evolution patterns, and driving factors of China and ASEAN countries within the regional intermediate goods trade network holds significant theoretical value and urgent practical relevance for scientifically identifying regional comparative advantage patterns, accurately diagnosing the resilience shortcomings of industrial and supply chains, and formulating strategies for collaborative upgrading and security stabilization.

Based on the above background and research gaps, this paper focuses on three core research questions: What are the phased evolutionary characteristics of the overall topological structure of the China-ASEAN intermediate goods trade network during the period 2001-2022? How have the node positions, centrality levels, and functional roles of member countries in the trade network systematically evolved? How do the dynamic adjustments of the network structure affect the direction, scale, and efficiency of regional intermediate goods trade? To systematically address these questions, this paper uses panel data on bilateral intermediate goods trade between China and the ten ASEAN countries from 2001 to 2022, constructs a weighted trade network model with countries as nodes and bilateral trade intensity as link weights, and employs social network analysis to systematically characterize the spatiotemporal evolution trajectory and multidimensional structural features of the trade network, thereby providing empirical support for subsequent identification of influencing factors and policy optimization design.

2 Research Methods

To accurately characterize the complex economic linkages between China and ASEAN countries, this study constructs a directed weighted trade network with countries as nodes, based on intermediate goods trade data from 2001 to 2022. The network can be abstractly represented as a graph (G= (N, W), where N is the set of nodes countries, and W is the weighted adjacency matrix, with element (W_{ij}) representing the export value from country (i) to country (j), thus directly reflecting trade directions and flow intensities between countries（Lin,2026）[2].Drawing on social network analysis methods（Fagiolo,2010）[3], this study selects a series of indicators to measure the trade network at both macro overall and micro node levels: macro indicators are used to capture the global morphological characteristics of the network (Ma,2016)[4] , while micro centrality indicators identify the structural power and functional positioning of individual countries within the network (Chen,2016)[5].

2.1 Macro-level network indicators

2.1.1 Network Density.

Network density refers to the ratio of actual trade connections in the network to the maximum possible trade connections, measuring the universality and closeness of trade

links between countries. Higher network density indicates more extensive direct trade connections among countries and a higher level of regional economic integration.

2.1.2 Average Distance.

Average distance is the average number of "steps" along the shortest paths between all possible pairs of country nodes in the network. It measures the ease and efficiency with which goods and trade influence propagate through the network. A shorter average path length indicates higher efficiency of direct or indirect trade links between countries and better overall network connectivity.

2.1.3 Network Symmetry Index.

The network symmetry index quantifies the balance and reciprocity of trade flows between countries, reflecting the degree of equivalence in bilateral trade relations. A higher network symmetry index indicates a large number of balanced trade relationships within the region, serving as an important indicator of deep interdependence between countries. The index is calculated by constructing a difference matrix (Q) using the following formulas:

$$E(Q) = w - (1 - w)I_n \tag{1}$$

$$E(I) = 1 - \frac{\sum_i \sum_j q_{ij} q_{ji}}{\sum_i \sum_j {q_{ij}}^2} \tag{2}$$

where w represents trade values between nodes, I_n represents the identity matrix of order (n), (SI) is the network symmetry index, (q_{ij}) represents the trade value from country (i) to country (j), and (q_{ji})) represents the trade value from country (j) to country (i).

2.2 Node-level indicators

2.1.1 Degree Centrality.

In a sectoral trade network, the degree centrality of a node is divided into out-degree and in-degree, reflecting the breadth of direct forward and backward trade links established by that country. Higher degree centrality indicates that the country has more direct upstream and downstream trading partners, and thus greater activity and participation in the overall trade network.

2.1.2 Betweenness Centrality.

Betweenness centrality measures a country's ability to serve as a "bridge" or "intermediary" between other countries in the trade network. It is calculated as the proportion of all shortest trade paths that pass through that node. In value chain trade networks, countries with high betweenness centrality are typically key intermediate goods suppliers, core circulation nodes, or hubs of technical standards, exerting significant control and bottleneck effects over the smooth operation of industrial chains.

2.1.3 Closeness Centrality.

Closeness centrality is defined as the sum of the shortest path distances from a given node to all other nodes in the network. In trade networks, it measures a country's ability to independently and quickly access market information, technology, or resources without being constrained by other links. Lower closeness centrality indicates that a country can reach the entire network through fewer intermediate links, thereby possessing greater agility and independence in responding to changes in market demand or external shocks.

2.1.4 Eigenvector Centrality.

Eigenvector centrality not only considers the number of a country's own trade connections but also emphasizes the importance of the nodes it connects to. It effectively identifies countries that are at the core of network influence due to their high-quality connections. Even if a country has few direct trade connections, if it connects to highly influential core countries in the network, its eigenvector centrality will still be high.

3 Analysis of the Structural Evolution of the China-ASEAN Intermediate Goods Trade Network

3.1 Dynamic Evolution of Network Structure

Based on the complete topological indicator data of the China-ASEAN intermediate goods trade network from 2001 to 2022, the analysis reveals that the regional network structure exhibits dynamic evolutionary characteristics characterized by continuously deepening connectivity, gradually improving efficiency, but significantly fluctuating equilibrium. The temporal changes in network density, average distance, and symmetry index clearly depict the complete trajectory of the regional production network from initial formation, through external shocks, to adjustment and recovery.

During the observation period, network density steadily and consistently increased. This is the combined result of the advancement of the China-ASEAN Free Trade Area, the implementation of bilateral investment agreements, and the spontaneous integration of regional supply chains, indicating that regional economic linkages have been continuously "woven tighter." Although the growth rate is modest, the sustained upward trend reflects the long-term and gradual nature of the expansion of the regional trade network, with its connectivity breadth and structural robustness being systematically enhanced.

The average network distance shows a stable and slow downward trend. The core driving factors include: first, the trade intermediation capacity and connectivity range of key regional hub nodes continue to strengthen, providing more shortcuts for cross-border circulation; second, the proportion of direct trade connections increases, reducing intermediate links in the flow of goods. This change effectively reduces trade and time costs within the regional value chain and enhances the network's responsiveness to changes in market demand.

In contrast to the smooth evolution of the first two indicators, the network symmetry index fluctuates violently during the observation period and shows an overall downward trend, revealing two core facts: First, the trade network has inherent structural asymmetry, stemming from differences in the positions of the two sides in the global value chain—China focuses more on upstream intermediate goods and capital goods trade, while ASEAN leans more toward downstream resource goods and final consumer goods trade. Differences in industrial structure determine the inherent imbalance of the trade network. Second, the network's balance is susceptible to external macroeconomic shocks. The fluctuating decline after 2011 and the cliff-like drop in 2020 are closely related to the rise of trade protectionism after the global financial crisis, supply chain adjustments triggered by the Sino-US trade friction, and the COVID-19 pandemic. The sharp drop in 2020 directly reflects the trade imbalance caused by supply chain disruptions in the early stage of the pandemic. External shocks have had a lasting structural impact on the network, while shortcomings in crisis response, capacity backup, and the construction of diversified channels have limited the recovery speed of the trade network's symmetry, requiring a long period of adjustment for its restoration..

3.2 Dynamic Evolution of Nodes in the China-ASEAN Industrial Chain Trade Network

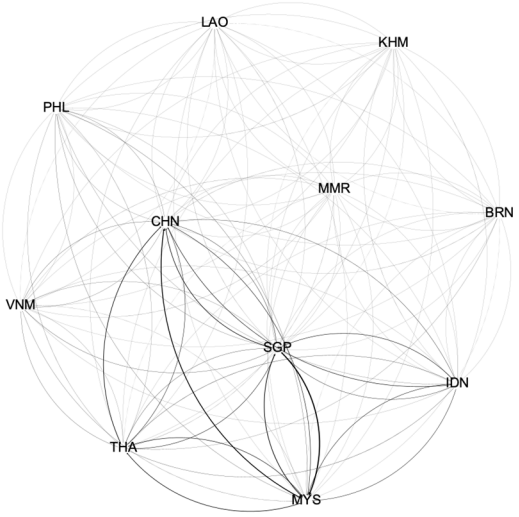

Fig. 1. The China-ASEAN Trade Network.

By 2022, the China-ASEAN trade network had evolved into a multi-center structure, with China remaining the top node but its relative advantage narrowing significantly as Vietnam, Thailand, Malaysia, and Singapore emerged as key secondary hubs. In terms of degree centrality, several ASEAN countries saw substantial gains, reflecting diversified trade links and reduced sole dependence on China. Changes in betweenness centrality were particularly notable: China’s value dropped while those of Vietnam and

Singapore rose, indicating more diverse trade paths and weakened reliance on China as the sole intermediary. Meanwhile, closeness centrality values across countries converged, improving overall network resilience and reducing path dependence on any single node. Regarding eigenvector centrality, China's core influence persisted, but Singapore and Vietnam gained key positions in the diffusion of trade influence, creating a pattern with China at the center and multiple high-influence nodes coordinating alongside. As shown in Figure 1.

4 Conclusion

This paper studies the 2001–2022 China-ASEAN intermediate goods trade network. The network evolves from unipolar to multipolar interdependence, with higher density and shorter average distance. The symmetry index declines under external shocks. China stays core but its advantage narrows; Vietnam, Thailand, Malaysia and Singapore become key hubs. The multipolar structure enhances resilience and deepens regional value chain integration. These findings suggest that deepening intra-ASEAN production linkages and fostering diversified trade channels can further mitigate systemic risks and support the sustainable upgrading of the regional industrial chain under global uncertainty.

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