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Trade Patterns and Green Transformation of Fats and Oils in BRICS: Supply Chain Resilience and Sustainability Perspectives

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Abstract. The fats and oils industry is central to food security, industrial production, and bioenergy, but it is increasingly challenged by supply chain risks and environmental pressures. With the expansion of BRICS to include Egypt, Ethiopia, Iran, Saudi Arabia, and the United Arab Emirates, this group of countries now accounts for nearly half of global oilseed production and consumption and more than 40% of vegetable oil imports. Using panel data on production, consumption, and trade flows, this paper analyzes the evolving trade patterns of fats and oils in BRICS countries and evaluates the potential for a green transformation of the sector. Results show that BRICS exhibits strong trade complementarities: agricultural exporters such as Brazil and Argentina complement resource-driven economies like Saudi Arabia and the UAE, while China plays a central role as a consumer and logistics hub. However, structural dependence on soybeans and palm oil, along with environmental risks such as deforestation and water stress, pose challenges to sustainable supply chain security. Econometric analysis confirms that population growth and investment freedom are key drivers of trade expansion, while high labor shares reflect inefficiencies in industrial restructuring. The study contributes to logistics and service science by highlighting the importance of diversified sourcing, resilient trade corridors, and digitalized supply chain monitoring in securing fats and oils trade. Policy recommendations include strengthening green technology transfer, promoting multimodal logistics hubs, and cultivating demand for certified sustainable oils in BRICS markets to balance trade growth with ecological sustainability.

Keywords: BRICS, fats and oils, trade patterns, supply chain resilience, sustainability, logistics

1 Introduction

The fats and oils sector are a critical component of the global food and energy system, underpinning food security, industrial applications, and biofuel production. Demand continues to expand, driven by population growth, dietary changes, and renewable energy requirements. At the same time, the industry faces mounting sustainability challenges, including deforestation, biodiversity loss, and water scarcity, especially in major soybean and palm oil producing regions. For emerging economies, securing stable supply chains of fats and oils has become a strategic priority, linking agricultural production, logistics infrastructure, and international trade.

The expansion of BRICS in 2024 to include Egypt, Ethiopia, Iran, Saudi Arabia, and the United Arab Emirates has reshaped global trade dynamics. Collectively, BRICS now accounts for nearly half of global oilseed production and consumption and more than 40% of vegetable oil imports, underscoring its central role in the global fats and oils supply chain. However, most existing studies analyze BRICS agricultural trade from a macroeconomic or food security perspective, with limited attention to logistics integration, supply chain resilience, and the green transformation of fats and oils trade. There is also insufficient empirical evidence on how population, labor structures, and investment freedom influence trade volumes in the expanded BRICS context.

This study addresses these gaps by systematically examining the production, consumption, and trade patterns of fats and oils in the expanded BRICS countries, with a focus on sustainability and supply chain security. Using panel data and econometric modeling, it identifies the drivers of trade volume and assesses the potential for a green transformation of the sector. The contributions are threefold: (1) mapping the evolving trade patterns of fats and oils in BRICS and revealing complementarities between agricultural exporters and resource-driven economies; (2) linking trade dynamics to logistics and service science by highlighting the role of trade corridors, ports, and digitalized monitoring systems in enhancing supply chain resilience; and (3) providing sustainability-oriented policy recommendations to promote green technology transfer, diversify sourcing strategies, and cultivate demand for certified sustainable oils. By combining trade analysis with supply chain and sustainability perspectives, the study offers new insights for academics, policymakers, and industry stakeholders seeking to balance growth with ecological responsibility.

1.1 Background of the Study

In recent years, the role of BRICS countries in the global fats and oils trade has become increasingly prominent, driven by their vast market size, abundant agricultural resources, and deepening economic collaboration. The original members—China, Brazil, Russia, India, and South Africa—had already established clear patterns of specialization in commodities such as soybeans, sunflower oil, and cottonseed oil. With the addition of new members such as Saudi Arabia, Egypt, Iran, and others, the group's influence on global trade structures has further expanded, creating new expectations for sustainable supply chains and deeper regional integration.

Despite these opportunities, the trade structure of BRICS remains highly concentrated on a few commodities, notably soybeans, palm oil, and sunflower oil. This heavy reliance reflects each country's resource endowments and consumption patterns, but it also exposes the supply chain to risks associated with ecological stress and regional instability. The absence of diversification strategies makes the system vulnerable to shocks, while unchecked expansion of oilseed cultivation has raised concerns about land use, deforestation, and biodiversity loss. In ecologically fragile areas such as tropical rainforests, arid zones, and grasslands, large-scale agricultural activity further exacerbates soil degradation, water scarcity, and climate-related vulnerabilities.

The environmental externalities of fats and oils production are evident in rising greenhouse gas emissions, biodiversity loss, and water stress linked to land conversion and monoculture farming. While some BRICS countries have introduced ecological redlines, certification schemes, and conservation

measures, such policies are often fragmented and uneven in enforcement. This has created a "leakage effect," where restrictions in one region drive production to other less regulated but equally fragile areas, intensifying overall ecological risks.

Policy interventions in BRICS countries also generate spillover effects across member states. Adjustments in subsidies, processing quotas, and import structures can strengthen food security and competitiveness domestically, but without embedding sustainability goals, they may inadvertently increase environmental pressures elsewhere in the bloc. As BRICS expands its trade and influence, reconciling economic gains with environmental stewardship has become a pressing governance challenge. Ensuring compatibility between trade growth, environmental protection, and long-term supply chain resilience will therefore be critical to achieving a truly green transformation in the fats and oils sector.

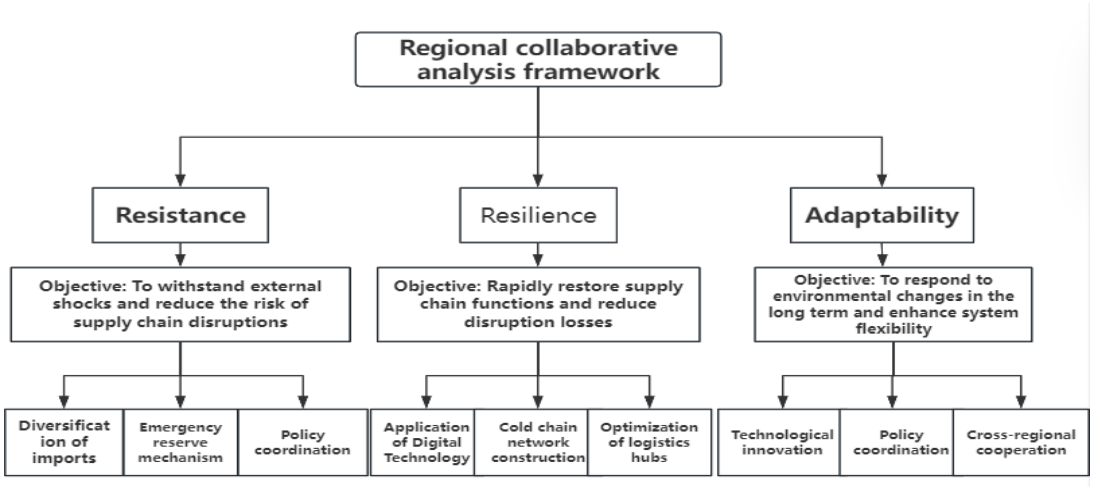

Fig1: Regional collaborative analysis framework.

1.2 Significance of the Study

The green transformation of the fats and oils sector in BRICS countries carries profound significance at multiple levels. At the global scale, it directly supports the realization of the United Nations Sustainable Development Goals and the climate commitments outlined in the Paris Agreement, given that agriculture remains a major source of greenhouse gas emissions. With BRICS countries together responsible for a large share of global emissions and food demand, their ability to transition toward sustainable practices will shape both international climate governance and long-term food security.

From an economic perspective, promoting sustainability in fats and oils production is not merely an environmental obligation but also an opportunity for competitiveness. Producers that meet international sustainability standards can access high-value markets, comply with emerging regulations such as the EU Deforestation Regulation, and avoid potential trade barriers. At the same time, sustainable practices such as climate-resilient agriculture, circular resource use, and eco-certification create new growth areas in green technologies and value-added processing, while also reducing production risks in volatile markets.

The environmental dimension is equally critical. Transitioning toward sustainable production can help reduce deforestation, protect soil and water resources, and maintain biodiversity in ecologically fragile regions. Green practices such as improved irrigation, optimized fertilizer use, and ecosystem restoration not only lower the ecological footprint of the fats and oils industry but also safeguard the long-term viability of agricultural systems. This shift is essential to balance rising demand with environmental stewardship.

Beyond the global and ecological scales, the transformation has wide-ranging social implications.

Sustainable agricultural practices can stabilize yields, reduce costs for farmers, and improve rural livelihoods. Strengthening domestic food systems reduces dependence on volatile international markets and reinforces national food sovereignty. Furthermore, ensuring that smallholders and vulnerable groups benefit equitably from the transition is vital to avoid marginalization and to promote inclusive rural development. By improving rural living conditions, attracting investment, and encouraging talent return, the green transition can also contribute to broader rural revitalization across BRICS countries.

In addition, taking a leadership role in sustainable agriculture enhances BRICS' legitimacy in global governance. Demonstrating effective action in balancing trade expansion with ecological responsibility can strengthen the group's soft power and credibility. Conversely, failure to address environmental risks in agricultural trade could weaken BRICS' reputation as a responsible global actor. This study is therefore significant in providing a framework for how BRICS countries can align trade growth with sustainability, securing both strategic advantage and ecological resilience.

1.3 Research Framework and Contribution

This study is designed around a clear research framework that links background analysis, data investigation, empirical testing, and theoretical interpretation to provide a comprehensive understanding of the fats and oils trade in the expanded BRICS grouping. First, it examines the policy and structural context of both original and newly joined BRICS members, analyzing their agricultural development strategies, trade patterns, and sustainability challenges. Second, it integrates global panel data on oilseed production, consumption, and trade, allowing for comparative analysis of the new members' positions within the global fats and oils supply chain. Third, the study employs econometric models to quantify the external factors—such as population growth, labor structure, and investment freedom—that influence trade flows and supply chain resilience. Fourth, by combining regression analysis with sustainability perspectives, it evaluates how demand for vegetable oils such as soybeans and sunflower oil interacts with ecological pressures and market dynamics. Finally, guided by industry chain resilience theory, it constructs a regional synergy framework that connects agricultural efficiency, logistics hub functions, and sustainability-oriented trade strategies to clarify the strategic positioning of BRICS in global fats and oils markets.

The research is underpinned by three qualities that strengthen its contribution. From a scientific perspective, it is based on real-world developments—namely, the expansion of BRICS and its growing role in global agricultural trade—using empirical methods to provide reliable evidence for both academic analysis and policy decision-making. From an advancement perspective, it moves beyond earlier studies that focused either on traditional BRICS members or on global agricultural trade in general, by specifically examining fats and oils within the context of the expanded group and by linking trade with sustainability and new energy transitions. From a uniqueness perspective, it addresses questions rarely covered in existing research, such as the impact of new BRICS members like Saudi Arabia, Egypt, and the UAE on fats and oils trade and their role in advancing sustainable energy and agricultural practices. By targeting the intersection of trade, logistics, and sustainability, this study provides original insights into how the expanded BRICS can balance economic growth, food security, and ecological responsibility.

2 Policy Research

2.1 Overview of Bilateral and Multilateral Trade Agreements among BRICS (BRICS+) members

Table 1: Formal Bilateral Trade Agreements (FTA, CEPA, PTA)

Type of agreement	Participating Countries	Status	Main contents and objectives
CEPA (Comprehensive Economic Partnership Agreement)	India - UAE	Entry into force (May 2022)	Covers goods, services, investment, digital trade, etc.; target trade in goods of $100 billion; tariffs to be completely eliminated within ten years
PTA (Preferential Trade Arrangement)	India - South Africa (SACU)	Under negotiation (restarted in April 2025)	Pharmaceuticals, agriculture, MSME cooperation, local currency settlements, etc.; positive list style
FTA (Free Trade Agreement)	Mercosur (Brazil) - Egypt	Entry into force (2010)	Tariff concessions on industrial goods, deepening South America-Africa trade links
PTA (Preferential Trade Arrangement)	India - Mercosur (Brazil)	Entry into force (2009)	Tariff concessions on designated list goods, limited coverage

Table 2: Strategic/framework bilateral cooperation treaties (non-tariff agreements)

Type of agreement	Participating Countries	Status	Main contents and objectives
Strategic Partnership Treaty (Comprehensive)	Russia - Iran	Entry into force (April 2025)	20-year term; cooperation in energy, transportation, finance, science and technology; deepening connectivity in the context of countering sanctions
Comprehensive Cooperation Program (CSP)	China - Iran	Signed (2021)	Strategic + economic cooperation; covers energy, ports, transportation, telecom; dovetails with Belt and Road, slower implementation
Strategic Collaborative Partnership (SCP)	China - Russia	Running	No FTA; cooperation within the framework of the EAEU-China Agreement; covers economy, security, energy
Partnership for Development (PGD)	China - South Africa	Moving forward	Optimization of South Africa's export structure; encourages investment in mineral processing; no formal tariff arrangements

Table 3: Members with Strong Trade Relationships but No Formal Agreements

Country Relations	Characteristics	Description
China - Brazil	Strong trade flows	China is Brazil's largest trading partner; focus on agricultural and resource exports, no formal FTAs
China - UAE	High bilateral trade	Trade value of $86.7 billion by 2023; no CEPA or FTA in sight, negotiations likely through GCC

Country Relations	Characteristics	Description
Egypt - UAE	High investment cooperation	Multiple MOUs on data centers, digital infrastructure, transportation, etc.; no formal agreements at this time

Table 4: Indirect links through regional agreements

Regional organizations	BRICS member countries	Corresponding trade links
Mercosur	Brazil	Linkages with Egypt (FTA), India (PTA)
SACU	South Africa	PTA negotiations with India; China through PGD cooperation
AfCFTA	Egypt, Ethiopia, South Africa	Promoting intra-African free trade and industrial integration
EAEU	Russia	FTA with Iran; under negotiation with India, UAE, Egypt, Indonesia

Table 5: Key agreements under negotiation (some involving BRICS members)

Proposed Agreement	Participating Countries	Status	Description
EAEU - India FTA	Russia - India	Pre-negotiation, 2025 launch expected	Feasibility study completed
EAEU - UAE FTA	Russia - UAE	Negotiations completed, 2025 pending signature	Initially covers trade in goods
EAEU - Indonesia FTA	Russia - Indonesia	Negotiations underway, expected to be signed within 2025	Progressing well
GCC - China FTA	UAE/Saudi Arabia (GCC) - China	Under negotiation, blocked	Negotiations have been stalled for a long time as Saudi Arabia is concerned about industry shocks
India - SACU PTA	India - South Africa (SACU)	Negotiations restarted in April 2025	Focus on specific industries and market access

The lack of harmonized bloc FTAs and trade linkages among BRICS (BRICS+) members are mainly constructed through three paths: 1. formal bilateral agreements (e.g., CEPA/PTA); 2. strategic partnership framework agreements (energy, investment-oriented); and 3. indirect linkages through regional blocs (e.g., EAEU, Mercosur, AfCFTA). The current trend of comprehensive agreements represented by CEPA is on the rise, while the degree of integration is still low and the network structure is mostly polycentric and loose.

2.2 Oil and Oilseed Policy Dynamics in New BRICS Members

The expansion of BRICS to include Egypt, Ethiopia, Iran, Saudi Arabia, and the United Arab Emirates has significantly reshaped the policy landscape surrounding fats and oils trade. Each of these new

members brings distinct institutional approaches, shaped by their agricultural endowments, economic priorities, and resource constraints, yet together they highlight common challenges in balancing food security, industrial upgrading, and sustainability.

Egypt illustrates a model of tariff-based industrial policy. By exempting oilseed imports such as soybeans and sunflower seeds from tariffs while taxing processed oils, the government has encouraged the development of local crushing and processing capacity. This approach strengthens domestic value chains but also entrenches Egypt's high dependence on external raw materials, exposing vulnerabilities during global price volatility and foreign exchange shortages. In contrast, Ethiopia has historically relied on exporting primary oilseeds such as sesame while importing most of its edible oils, creating a structural imbalance of "export raw materials, import finished goods." Current reforms, including agro-industrial parks and processing initiatives, aim to localize value addition and reduce foreign dependence, but they raise concerns about land use sustainability and inclusiveness.

Iran's oilseed policy reflects the dual pressures of sanctions and domestic self-sufficiency goals. Measures such as tariffs on imports, targeted subsidies, and reserve systems are designed to stimulate local production while ensuring consumer affordability. Yet geopolitical constraints and logistical bottlenecks limit policy effectiveness, forcing frequent adjustments between protecting livelihoods and supporting producers. Saudi Arabia presents a different model, leveraging its oil-based economy to secure fats and oils through global investment, imports, and strategic reserves rather than large-scale domestic cultivation. Anchored in its Vision 2030 agenda, the kingdom emphasizes water-saving agriculture, biofuel development, and diversification of overseas supply sources to ensure long-term security.

The United Arab Emirates combines trade openness with strong regulatory oversight. Rejecting self-sufficiency, it relies on diversified imports, robust logistics infrastructure, and biofuel innovation, particularly sustainable aviation fuel from waste cooking oil, to secure supply while aligning with its 2050 net-zero strategy. Together, these Gulf states demonstrate how resource-based economies can externalize food security while positioning themselves as logistics hubs and technology leaders.

A cross-cutting analysis of the five new members reveals several common themes. First, all rely heavily on trade liberalization and foreign partnerships to stabilize supply, whether through tariff structures, foreign direct investment, or overseas agricultural ventures. Second, sustainability is increasingly embedded in national strategies, though implementation remains uneven: while countries like the UAE promote technology-driven biofuel initiatives, others struggle with policy oscillation or land-use risks. Third, policy fragmentation creates risks of "leakage effects," where environmental restrictions in one area shift production to less regulated regions, exacerbating ecological pressures. Finally, the policies of new BRICS members often generate spillover effects across the bloc, influencing trade flows, investment incentives, and sustainability outcomes. Coordinating these diverse approaches within a BRICS+ framework will be essential to strengthen supply chain resilience, harmonize standards, and promote a collective green transformation in fats and oils trade.

2.3 Sustainable Development and BRICS Cooperation

The expansion of BRICS to include Egypt, Ethiopia, Iran, Saudi Arabia, and the United Arab Emirates in 2024 has created new opportunities for aligning trade growth with sustainable development. These countries face pressing challenges of energy security, food supply, and ecological stress, but BRICS membership provides access to financial resources, technology transfer, and institutional cooperation that can accelerate their transition toward sustainability.

Clean energy investment is one of the most visible areas of progress. Projects such as Egypt's Benban Solar Park and Aswan Photovoltaic Industrial Park, Ethiopia's Renaissance Dam wind power expansion, Saudi Arabia's NEOM green hydrogen initiative, and the UAE's Mohammed bin Rashid Solar Park demonstrate how BRICS financing and technical support can directly advance UN

Sustainable Development Goals, particularly SDG7 (Affordable and Clean Energy), SDG9 (Industry, Innovation, and Infrastructure), and SDG13 (Climate Action). These projects not only reduce carbon emissions but also create employment, lower industrial energy costs, and strengthen local development capacity, showcasing how clean energy and agricultural resource management can complement each other.

The socio-economic effects of BRICS cooperation extend beyond energy. By providing financing through the New Development Bank and encouraging infrastructure and technology partnerships, BRICS projects enhance food security, industrial upgrading, and social equity. For example, renewable energy projects in Egypt and Ethiopia have reduced electricity costs while creating thousands of jobs, while technical training and educational initiatives have built human capital for long-term resilience. Such outcomes highlight how sustainable development is not limited to environmental benefits but also contributes to poverty reduction, improved livelihoods, and rural revitalization.

At the same time, the success of these initiatives depends on cultivating local demand for sustainable products and ensuring equitable participation. Without sufficient consumer pull for certified sustainable oils and biofuels within BRICS markets, producers may have limited incentives to adopt higher environmental standards. Conversely, strong domestic demand in large markets such as China and India could trigger wider adoption of sustainable production practices in export-oriented economies like Brazil and new members in the Middle East and Africa. This dynamic underscores the importance of policy coordination, certification frameworks, and consumer awareness in driving the green transition.

Finally, BRICS cooperation carries global significance. By demonstrating leadership in clean energy investment, sustainable agriculture, and inclusive development, BRICS can enhance its legitimacy in international governance and strengthen its influence in shaping global sustainability norms. Conversely, if expansion results in rising trade of unsustainably produced commodities, BRICS risks reputational damage and loss of credibility as a responsible global actor. The challenge, therefore, lies in ensuring that trade, logistics, and investment flows within BRICS are systematically aligned with sustainability goals. This study contributes by analyzing these dynamics and highlighting strategies through which BRICS can leverage its collective strength to promote a balanced, resilient, and sustainable future.

3 Fats and Oilseeds Production and Consumption in The New BRICS Countries

3.1 Oilseed production

In terms of production, there are significant differences in the production of oilseeds and their products among countries. Taking soybean as an example, Egypt's soybean production is relatively high, reaching 850,000 MT, while Iran's production is lower. In addition, each country has developed its own distinctive oilseed crop industry according to its own agricultural resources and climatic conditions. For example, Egypt produces large quantities of oilseeds such as cottonseed and peanut in addition to soybean, while Iran focuses on sunflower production.

Table 6: New BRICS countries' oilseed and oil production and their share of global

Oilseeds	Output/10,000 t		Percentage
	BRICS	Global	
Soybean	474.2	474.2	1.19%
Rapeseed	162.5	8800.7	1.85%
Cottonseed	35.7	4166	0.86%
Peanut	20.5	5046	0.41%
Sunflower seed	13.7	5491	0.25%

copra	0	603	0.00%
palm kernel	0	2071	0.00%
Total	706.6	65862.7	1.07%

The UAE, on the other hand, has performed well in terms of exports of oilseed crops, especially rapeseed oil and palm oil. At the same time, the country also imports a certain amount of oilseed crops, but the imports appear to be small compared to its exports. This reflects the fact that the UAE may have a strong production and export capacity in the field of oilseed crops.

3.2 Consumption of oilseeds

Table 7: New BRICS countries' consumption of oils and oilseeds and their share of global

Oilseeds	Consumption/10,000 t		Percentage
	BRICS	Global	
Soybean	6464	383796	1.68%
Rapeseed	1085	88023	1.23%
Cottonseed	166	41283	0.40%
Peanut	160	49276	0.32%
Sunflower seed	206	56645	0.36%
copra	0	6211	0.00%
palm kernel	0	20193	0.00%
Total	8081	645427	1.25%

The consumption of oilseeds in the newly joined BRICS countries reflects both structural demand for food security and growing diversification into industrial and renewable energy uses. In 2023/2024, total oilseed consumption among these countries reached 80.81 million tons, accounting for around 1.25% of global demand (table 7). Soybeans dominate consumption, followed by rapeseed, cottonseed, sunflower seed, and peanuts, broadly aligning with production patterns but also highlighting significant import reliance.

Soybeans represent the largest share of demand, driven primarily by processing for edible oils and animal feed. China's strong crushing demand indirectly raises import requirements for other members, while Egypt and Ethiopia rely on imports to sustain domestic food production and livestock industries. Rapeseed consumption has also expanded steadily, supported by global supplies from Canada and Australia and by increasing domestic crushing capacity in Egypt and Iran. Sunflower seeds show marked growth in demand, particularly in the UAE and Iran, reflecting consumer preferences for healthier oils. Cottonseed and peanut consumption remain modest but play a role in diversifying local food and feed supply.

The drivers of oilseed consumption growth are multifaceted. Rapid population growth and urbanization in Egypt and Ethiopia increase demand for processed foods and edible oils, while the Gulf states emphasize dietary diversification and catering industries. Rising health awareness is shifting consumption toward sunflower and olive oils, especially in Iran and the UAE. At the same time, energy transition policies are gradually creating new demand for oilseeds as biofuel feedstocks, reinforcing their dual role in food and energy security.

Overall, oilseed consumption in the expanded BRICS bloc is moving beyond traditional food uses toward a more complex demand structure that combines food security, industrial processing, and renewable energy development. This shift underlines the group's growing importance in global oilseed markets and calls for stronger logistics systems, diversified sourcing, and sustainable consumption policies to ensure long-term supply chain stability.

3.3 Vegetable Oil Production

Table 8: Total production of vegetable oil in the new BRICS countries and their share of global

Oil	Output/10,000 t		Percentage
	BRICS	Global	
Soybean oil	1206	6168	19.55%
Peanut oil	205	614	33.39%
Sunflower seed oil	64	2166	2.95%
Cottonseed oil	34	495	6.87%
Rapeseed oil	0	3379	0.00%
Palm oil	0	7946	0.00%
Copra oil	0	377	0.00%
Palm kernel oil	0	910	0.00%
Olive oil	0	229	0.00%
Total	1509	22284	6.77%

Vegetable oil production in the newly joined BRICS countries remains modest in global terms but shows clear areas of specialization that complement broader BRICS supply networks. In 2023/2024, the five countries produced approximately 15.09 million tons of vegetable oil, representing about 6.8% of global output (table 8). Production is highly concentrated in soybean, peanut, sunflower, and cottonseed oils, with negligible capacity in palm, rapeseed, and other tropical oils.

Soybean oil dominates, with Egypt and Iran emerging as the main contributors. Together they account for nearly one-fifth of global soybean oil production, reflecting their growing crushing capacity and domestic demand. Peanut oil is another area of strength, particularly in Egypt, which contributes more than one-third of global supply. In contrast, sunflower and cottonseed oils are produced on a smaller scale but still play an important role in supporting domestic consumption and regional exports. By comparison, production of palm oil, rapeseed oil, and other specialty oils remains minimal, underscoring a structural dependence on imports for these commodities.

The production structure highlights both opportunities and risks. On the one hand, specialization in soybean and peanut oil gives the new BRICS members leverage in certain niche markets, while domestic processing capacity contributes to local value addition. On the other hand, limited diversification increases vulnerability to supply disruptions, price volatility, and environmental stress in a few concentrated crops. The reliance on imported palm and rapeseed oils also creates a logistics burden, particularly for Gulf states, where food processing industries depend on stable import flows through ports such as Jeddah and Dubai.

From a supply chain perspective, expanding processing efficiency, diversifying crop portfolios, and strengthening multimodal transport links will be essential to improve resilience. In addition, introducing sustainable production practices—such as water-saving irrigation and eco-certification in soybean and peanut oil chains—can enhance competitiveness in international markets that increasingly demand traceable and environmentally responsible products.

3.4 Vegetable Oil Consumption

Table 9: New BRICS countries' global oil consumption

Oil	Egypt	Ethiopia	Iran	Saudi Arabia	United Arab Emirate
Soybean oil	740	13	965	85	35
Peanut oil	0	0	0	0	0
Sunflower seed oil	550	0	800	125	0
Cottonseed oil	19	0	23	0	0
Rapeseed oil	0	18	140	0	60

Palm oil	1170	30	450	600	315
Copra oil	0	0	0	0	0
Palm kernel oil	0	0	4	10	0
Olive oil	0	0	0	27	0
Total	2479	61	2397	847	410

The consumption of vegetable oils in the newly joined BRICS countries reflects both rising food security needs and evolving dietary preferences. In 2023/2024, combined demand reached approximately 6.2 million tons, accounting for about 3% of global vegetable oil consumption (table 9). Consumption is concentrated in a few major oils—soybean, palm, and sunflower—which together dominate household, industrial, and catering uses.

Soybean oil is widely consumed in Egypt and Iran, supported by domestic crushing capacity and strong demand from the food industry. Palm oil consumption is highest in Saudi Arabia and the United Arab Emirates, where low prices, wide applicability, and strong demand from the catering sector drive imports. Sunflower oil has gained traction in Iran and Ethiopia, reflecting consumer preferences for healthier oils rich in unsaturated fatty acids. Smaller volumes of rapeseed and olive oil are also consumed, particularly in wealthier markets such as the UAE, though their overall shares remain limited.

Several factors explain these trends. Rapid population growth and urbanization in Egypt and Ethiopia have significantly raised demand for edible oils, especially for processed and convenience foods. In the Gulf states, income growth and urban lifestyles have expanded the catering sector, supporting demand for palm oil. Rising health awareness has created space for sunflower and olive oils, particularly among middle-class consumers in Iran and the UAE. Looking forward, the demand for oils with perceived health benefits is expected to grow, while palm and soybean oils will continue to serve as cost-effective staples.

From a supply chain perspective, the heavy reliance on imported palm and soybean oils highlights the importance of reliable trade corridors and resilient logistics systems. Gulf ports such as Jeddah and Dubai are already central to regional distribution, while Egypt's processing hubs play a key role in balancing local production with imports. Diversifying consumption patterns toward a broader mix of oils could reduce risks of overdependence on a few commodities, while promoting certified sustainable oils would align demand with environmental and social objectives.

4. Trade Pattern of Fats and Oils in the New BRICS Countries

Table 10: Oil imports by the new BRICS countries and their share of the global total

Oilseeds	**Import/10,000 t**		**Percentage**
	BRICS	**Global**	
Soybean	10113.17	39685	25.48%
Rapeseed	91.6	8800.7	1.04%
Cottonseed	5.1	4166	0.12%
Peanut	0.1	5046	0.00%
Sunflower seed	174	5491	3.17%
Copra	0	603	0.00%l
Palm kernel	1.8	2071	0.09%
Total	10385.77	65862.7	15.77%

Table 11: Oil exports by the new BRICS countries and their share of the global total

Oilseeds	**Export/10,000 t**	**Percentage**

	BRICS	Global	
Soybean	25.8	39685	0.07%
Rapeseed	72	8800.7	0.82%
Cottonseed	0	4166	0.00%
Peanut	1.5	5046	0.03%
Sunflower seed	7.9	5491	0.14%
Copra	0	603	0.00%
Palm kernel	8	2071	0.39%
Total	115.2	65862.7	0.17%

4.1 Import and export of oilseeds

The newly joined BRICS members play an increasingly active role in global oilseed trade, although their profiles are highly asymmetric. In 2023/2024, the group's combined oilseed imports reached 103.9 million tons, accounting for nearly 16% of the global total (table 10). Soybeans overwhelmingly dominate this flow, representing more than 97% of imports, which underscores the structural dependence of these countries on a single commodity. This reliance strengthens trade linkages with major exporters such as Brazil, Argentina, and the United States but also heightens vulnerability to supply disruptions, price volatility, and geopolitical shocks.

On the export side, volumes remain limited. The five new BRICS members together exported just 1.15 million tons of oilseeds—equivalent to 0.2% of global exports (table 11). The United Arab Emirates stands out as a niche exporter, particularly of rapeseed oil and soybean derivatives, supported by its strong re-export and logistics infrastructure. By contrast, Egypt and Ethiopia focus on domestic supply security, while Iran and Saudi Arabia remain net importers due to structural production gaps.

The trade profiles of these countries reveal clear complementarities. Resource-constrained economies such as Saudi Arabia and the UAE rely heavily on imports to meet growing food and feed demand, while Egypt and Ethiopia provide additional regional supply through oilseed cultivation and processing. Iran occupies a middle position, balancing moderate domestic production with significant import needs under the constraints of sanctions. This diversity suggests opportunities for intra-BRICS cooperation, particularly in reducing external dependency by leveraging processing hubs and optimizing logistics corridors.

From a supply chain perspective, the concentration of imports in soybeans highlights the urgent need for diversification toward alternative oilseeds such as sunflower and cottonseed. At the same time, the heavy import reliance of Gulf countries underscores the importance of secure and efficient logistics infrastructure. Ports such as Jeddah and Dubai already serve as key nodes for transshipment from South America to the Middle East, but greater investment in multimodal logistics, cold chain systems, and digital monitoring could further reduce risks of delays and losses. Overall, strengthening diversification and logistics integration will be critical to transforming oilseed trade from a vulnerability into a resilience-building mechanism for the expanded BRICS.

4.2 Vegetable Oil Imports and Exports

Vegetable oil trade in the newly joined BRICS members is characterized by high import dependence and relatively modest export capacity. In 2023/2024, total imports reached about 49.8 million tons—equivalent to 6.3% of global vegetable oil imports—while exports stood at only 8.3 million tons, or less than 1% of global exports. This imbalance highlights the structural reliance of these economies on external suppliers to meet growing domestic demand.

Among imports, sunflower oil, palm oil, and soybean oil dominate. Sunflower oil accounts for more than 11% of global import flows, reflecting strong demand in Egypt and Iran. Palm oil is heavily imported by Saudi Arabia and the United Arab Emirates, where it serves as a cost-effective staple for

the catering and food-processing sectors. Soybean oil imports remain significant, particularly for Egypt, which combines crushing capacity with rising consumption. By contrast, rapeseed and other specialty oils represent a smaller share but are gradually expanding as dietary diversification and industrial use increase.

Exports are concentrated in niche segments. The United Arab Emirates has developed into a re-export hub for processed oils, supported by its advanced logistics and free trade zones. Iran has modest but growing export flows to neighboring markets, facilitated by investments in domestic processing facilities. Other members, such as Egypt and Ethiopia, prioritize domestic supply security and export relatively small volumes.

From a supply chain perspective, several patterns stand out. First, the heavy reliance on imports underscores the strategic importance of trade corridors linking BRICS with major producers in South America, Southeast Asia, and the Black Sea region. Ports such as Alexandria, Jeddah, and Dubai are critical gateways for these flows and require continued investment in storage, cold chains, and digital trade monitoring to ensure reliability. Second, the re-export and processing role of the UAE illustrates how logistics infrastructure can turn import dependence into value-added opportunities. Finally, the uneven distribution of import and export capabilities across members suggests potential for intra-BRICS cooperation, such as joint procurement, shared reserves, and harmonized sustainability standards to strengthen collective bargaining power and resilience.

5 Theoretical Analysis and Econometric Modeling

5.1 Theoretical Analysis

Understanding the drivers of fats and oils trade in the expanded BRICS framework requires connecting classical economic theories with the realities of modern supply chains. Four perspectives are particularly relevant.

First, demand-pull and market size effects suggest that population growth directly stimulates trade volumes. As populations expand, domestic demand for edible oils, animal feed, and biofuel inputs increases, often beyond the capacity of local production. This demand surge creates strong incentives for imports and positions large consumer markets such as China, India, and Egypt as central nodes in global trade networks.

Second, market size not only reflects consumption but also influences supplier behavior. Countries with large populations and growing middle classes attract both domestic and international suppliers, which amplifies trade flows and intensifies competition. In the context of BRICS, this explains the persistent concentration of soybean and palm oil imports in populous economies while smaller members, such as Ethiopia, focus on ensuring food security through targeted imports.

Third, industrial restructuring theory highlights the role of labor and technology in shaping trade. A rising labor share may signal inefficiencies in industrial structures or reliance on resource-based sectors, which can reduce competitiveness in fats and oils production. Conversely, when economies shift toward capital- and technology-intensive agricultural practices—such as mechanized cultivation, advanced crushing facilities, and precision irrigation—they enhance value-added capacity, improve productivity, and increase their ability to participate in global trade.

Finally, theories of capital flows and investment freedom underscore the institutional dimension of trade performance. Greater openness to foreign and domestic investment attracts multinational firms into processing and logistics infrastructure, strengthens supply chain integration, and expands export capacity. For example, liberal investment policies in Egypt and the UAE have encouraged foreign investment in oilseed crushing and re-export hubs, thereby linking these countries more firmly to global supply chains. At the same time, restrictions driven by sanctions or weak institutional frameworks, as in Iran, limit the ability of investment freedom to translate into trade growth.

Together, these theoretical perspectives frame the empirical analysis of BRICS fats and oils trade. They suggest that population growth and investment liberalization act as trade stimulants, while structural inefficiencies in labor and industry can constrain competitiveness. For logistics and service science, this highlights the need to view trade not just as an outcome of resource endowment, but as the result of interlinked demographic, industrial, and institutional dynamics that shape supply chain resilience and sustainability.

5.2 Selection of external influence variables

Building on the theoretical framework, this study identifies three external variables that most directly influence the trade of fats and oils in the newly expanded BRICS countries: population, labor structure, and investment freedom. These factors are selected to reflect demographic demand pressures, resource endowments, and institutional conditions that shape supply chain performance.

Population growth is a fundamental driver of demand-pull effects, as highlighted in Section 5.1. Larger populations translate into higher consumption of edible oils, animal feed, and biofuel inputs, thereby expanding import requirements. For this study, the total population of each new BRICS country from 2010 to 2019 is used as a proxy for market size (POPULATION).

Labor share represents the proportion of the total population engaged in the workforce and serves as an indicator of resource endowment and industrial structure. A high labor share may reflect reliance on labor-intensive industries, whereas declining shares may signal a transition toward mechanization and technology-intensive agriculture. This variable (RESOURCE ENDOWMENT) is included to capture how workforce composition influences competitiveness in fats and oils trade.

Investment freedom captures the degree of openness and policy support for capital flows. Liberal investment environments can attract multinational firms, stimulate foreign direct investment in processing and logistics facilities, and improve overall supply chain efficiency. For this study, the investment freedom index published by the Heritage Foundation is used as a standardized measure (INVESTMENT FREEDOM).

Finally, to ensure data comparability and minimize distortions caused by the COVID-19 pandemic, trade and macroeconomic data from 2010 to 2019 are selected. By focusing on these three external influence variables, the model aims to quantify the demographic, structural, and institutional drivers of fats and oils trade in the BRICS+ countries and provide a basis for evaluating their implications for supply chain resilience and sustainability.

5.3 Selection of model

In this study, the total amount of import and export of the BRICS countries is taken as the explanatory variable, and the population, the proportion of labor force and investment freedom of the region are taken as the explanatory variables. Meanwhile, in order to better study the relationship between each explanatory variable and trade volume, this study decides to use the model as:

$$lnT = \beta_0 + \beta_1\, lnP + \beta_2\, lnR + \beta_3\, lnI + \varepsilon$$

Where, T is the dependent variable oil and grease trading volume (1000MT); P is the independent variable total population (10,000); R is the independent variable labor force share (%); and I is the independent variable investment freedom index.

5.4 Regression results and empirical analysis

According to the above way of model setting, the data are brought into the model for linear regression analysis, and the specific results are shown in Table 12.

Table 12: Regression results of model

lnT	Coefficient	std. err.	t	P>t	[95% conf. interval]	
LnP	4.794085	0.9155388	5.24	0.002	2.553842	7.034327
lnR	-20.71779	5.394395	-3.84	0.009	-33.9174	-7.518177
lnI	3.526978	0.9345353	3.77	0.009	1.240253	5.813704
_cons	-75.07082	7.474896	-10.04	0	-93.36123	-56.7804

As shown in the table, the coefficients of lnP and lnI are positive and both pass the 1% significance level test. This indicates that the total trade volume of fats and oils in the NBR countries is positively correlated with both total population and freedom of investment. Among its , the lnP coefficient of 4.794 (p=0.002) indicates that for every 1% increase in total population in the NBR countries, the trade volume of fats and oils significantly increases by about 4.79%. This result is highly consistent with the theory of "market size effect". Population increase may directly push up domestic food consumption demand and stimulate import growth, e.g. Saudi Arabia and UAE rely on food imports to meet the demand of population growth. In addition, the expansion of labor supply may enhance the processing and export capacity of agricultural products, especially in labor-intensive industries. Second, the coefficient of lnI is 3.527 (p=0.009), indicating that for every 1% increase in investment freedom, trade volume increases by 3.53%. This result suggests that institutional quality is a key driver of trade growth. A liberal foreign investment access policy will attract multinational companies to invest in agro-processing and logistics facilities, such as the foreign investment project in Egypt's palm oil processing plant, which will greatly enhance the quality and scale of export products. However, while population growth boosts trade in the short term, the lack of supporting infrastructure and technological upgrading will lead to marginal inefficiencies in trade. The effects of investment liberalization may also be subject to "institutional thresholds". As in the case of Iran, which is subject to international sanctions, external barriers may still offset institutional dividends even if domestic policies are relaxed.

However, the coefficient of the labor share (lnR) is -20.718 (p=0.009), which means that for every 1% increase in the labor share, the volume of trade falls by about 20.72%. This result is contrary to the expectations of the classical resource endowment theory, and we speculate that it may stem from the existence of limitations in measuring resource endowment in terms of the labor share or factors of modern agricultural technology. The trade structure of the NBR countries is highly dependent on natural resources (e.g., oil, minerals) rather than labor-intensive products. The high labor share may reflect the fact that resource abundance leads to industrial homogenization and inhibits the development of high value-added industries. Whereas the spread of agricultural mechanization and automation technology reduces the demand for low-skilled labor, a higher labor share may signal stagnant production efficiency.

5.5 Interpretation of model significance

The regression results offer important insights into how demographic, structural, and institutional factors shape the fats and oils trade in the expanded BRICS grouping. Three findings stand out.

First, population growth exerts a strong positive influence on trade volumes, confirming the market-size effect. Larger populations directly increase demand for edible oils and related products, stimulating imports in countries with production gaps. At the same time, this growth places greater pressure on natural resources such as land and water, making sustainable agricultural practices essential to balance rising demand with resource security.

Second, investment freedom also shows a significant positive relationship with trade, highlighting the role of institutions in attracting capital and integrating supply chains. Liberalized investment policies create opportunities for multinational firms to invest in agro-processing, logistics hubs, and storage facilities. This not only improves competitiveness but also strengthens resilience by diversifying sourcing channels and upgrading infrastructure. However, without clear environmental and social safeguards, investment liberalization may increase ecological stress or generate uneven development outcomes.

Third, the negative impact of labor share suggests that high reliance on labor-intensive production structures may reduce efficiency and limit competitiveness. In the BRICS+ context, this points to the importance of industrial upgrading, mechanization, and technology adoption in agriculture. Countries that successfully transition to capital- and knowledge-intensive production systems are more likely to expand their role in global fats and oils trade while reducing structural vulnerabilities.

Taken together, these results emphasize that trade in fats and oils is not solely a function of resource endowments, but rather the product of interconnected demographic, institutional, and technological dynamics. For logistics and service science, this underscores the need to view agricultural trade as part of a broader supply chain system where demand pressures, investment environments, and production efficiency jointly determine resilience and sustainability.

5.6 Regression analysis

The results of regression analysis show that all three factors, namely, population, freedom of investment, and labor share, can have a significant impact on the trade volume of oil and oilseeds in the new BRICS countries. Because this study aims to reveal the role and competitiveness of the BRICS countries in the global trade of fats and oils, it is analyzed from the perspective of the impact generated by the accession of the five new BRICS countries. For the five countries, the proportion of population and labor force will not be affected much after joining the BRICS organization, while the freedom of investment will be significantly increased, which will help to increase the total trade volume of their oil and oilseed products. For the original BRICS member countries, the five countries of the oil and oil trade volume compared to the original members of the smaller, although it will not have too much impact on its original trade pattern, but it is better than nothing. Overall, the addition of new BRICS members will be beneficial to both the new BRICS countries and the original BRICS countries in terms of trade in oils and fats. Although it is not a fully complementary trade pattern, it is generally beneficial.

Based on the industry chain resilience theory, this paper integrates core elements such as agricultural production efficiency and logistics hub function to construct a regional synergy analysis framework: **(1) Resistance Strengthening Path**: China's imports of oilseeds from BRICS countries account for 68% of the global total, but soybean imports are over-concentrated, with the risk of a single source (e.g., Brazil accounts for more than 70% of the total). Document data show that Saudi Arabia, the United Arab Emirates and other Middle Eastern countries oilseed import demand is growing rapidly (2023/2024 vegetable oil imports accounted for 6.31% of the world) (U.S. Department of Agriculture, Foreign Agricultural Service, 2024), it is recommended to reduce the single-category dependence to less than 85% by expanding alternative sources such as Argentine sunflower, Iranian cottonseed, and so on. At the same time, the establishment of the BRICS Oilseeds Emergency Reserve Alliance and the sharing of inventory data (e.g., Egypt's soybean reserves can cover 3 months of demand) can effectively respond to supply chain disruptions caused by geopolitical conflicts (e.g., sunflower oil price volatility

of more than 40% in the Russia-Ukraine conflict in 2022) (USDA, 2024). **(2) Resilience enhancement mechanism**: Jeddah Port in Saudi Arabia and Dubai Port in the UAE serve as regional logistics hubs to undertake the transshipment function of Brazilian soybeans to the Middle East market). The documented case shows that Egypt has reduced the vegetable oil transportation loss rate by upgrading the cold chain facilities at the Port of Alexandria, verifying the direct contribution of logistics hub optimization to resilience. In addition, the application of blockchain technology in the "Brazil-UAE-Egypt" intermodal transportation model has shortened customs clearance time, further strengthening supply chain resilience. **(3) Innovative mechanisms for resilience**: Egypt's introduction of China's water-saving irrigation technology has boosted soybean yields by 15% (to 3.2 tons/ha), easing resource constraints in the Nile River Basin. The paper points out that Iran has improved the drought tolerance of sunflower seeds by 30% through anti-drought genetic improvement, providing a technological model for climate change adaptation. In terms of policy synergies, the BRICS Agricultural Science and Technology Corridor could jointly develop drought-tolerant varieties (e.g., Brazil-Iran cooperation to breed disease-resistant soybeans), which is expected to increase regional yields by 2% annually.

6. Discussion

This study examined the trade patterns and sustainability transition of fats and oils in the expanded BRICS grouping, using econometric analysis to assess how population, investment freedom, and labor structure influence trade volumes. The results reveal three key insights that contribute to both theory and practice.

First, population growth emerges as a central driver of fats and oils trade, supporting the classical market-size effect. Larger populations expand demand for edible oils, feed, and biofuel inputs, thereby increasing import reliance in countries with limited production capacity. This finding aligns with previous studies that emphasize demographic pressures as a primary determinant of agricultural trade flows. However, our analysis also highlights the sustainability dilemma: while population-driven demand growth promotes trade expansion, it simultaneously intensifies pressure on land, water, and ecosystems. Without resource-efficient production technologies, BRICS countries may face rising ecological risks that undermine long-term food and energy security.

Second, investment freedom shows a strong positive association with trade, confirming that institutional quality and openness to capital flows are crucial enablers of supply chain integration. Liberalized investment regimes attract multinational companies, foster agro-processing industries, and improve logistics infrastructure, all of which enhance competitiveness and resilience. This result is consistent with literature on the role of institutional quality in agricultural trade but adds nuance by demonstrating its particular relevance in the BRICS+ context. At the same time, our findings caution against assuming that investment liberalization automatically leads to sustainable outcomes. If environmental and social safeguards are weak, foreign investment may exacerbate deforestation, water stress, or social inequality. Thus, investment freedom must be paired with sustainability standards and regulatory oversight to yield balanced development benefits.

Third, the negative coefficient of labor share challenges conventional resource endowment theory. Rather than strengthening competitiveness, high reliance on labor-intensive production appears to signal structural inefficiencies and technological stagnation. This suggests that agricultural modernization and industrial upgrading are critical for BRICS countries to enhance their role in global fats and oils trade. Our results resonate with recent studies that emphasize the importance of mechanization, digital agriculture, and precision technologies in improving productivity. For logistics and service science, this finding underscores the need to integrate technology adoption not only in production but also in post-harvest handling, processing, and distribution systems to improve efficiency across the supply chain.

Beyond the quantitative results, the discussion reveals broader strategic implications. The

dominance of soybeans and palm oil in BRICS trade highlights a structural vulnerability to geopolitical shocks and environmental risks. Diversification toward alternative oilseeds such as sunflower, rapeseed, and cottonseed would reduce dependency while promoting ecological balance. Logistics hubs such as Jeddah, Dubai, and Alexandria play a pivotal role in shaping the resilience of these trade flows, and further investments in multimodal infrastructure, cold chain capacity, and digital monitoring can enhance supply chain security. Moreover, cultivating domestic demand for certified sustainable oils in major consumer markets like China and India is essential to incentivize greener production practices among exporters.

This study also carries limitations that point toward future research. The econometric model is based on trade data from 2010 to 2019 to avoid distortions caused by the COVID-19 pandemic, which may not fully capture more recent shifts in demand, logistics disruptions, or geopolitical realignments. Future studies could extend the analysis using post-2020 data, incorporate climate-related variables such as water stress or deforestation risk, and apply system dynamics or simulation approaches to capture supply chain complexity. In addition, more attention should be paid to intra-BRICS cooperation mechanisms, including joint reserves, harmonized sustainability standards, and digital trade platforms, which could significantly alter future trade dynamics.

In summary, the discussion highlights that the fats and oils trade in BRICS+ is shaped not only by resource endowments but by the interplay of demographic pressures, institutional frameworks, and technological capacity. By aligning trade strategies with sustainability imperatives, investing in resilient logistics, and fostering coordinated policy frameworks, BRICS countries can transform current vulnerabilities into opportunities for global leadership in sustainable agricultural trade.

7. Conclusion

This paper explored the evolving trade patterns of fats and oils in the expanded BRICS grouping, analyzing the drivers of trade flows and their implications for supply chain resilience and sustainability. The study confirmed that population growth significantly increases trade demand, investment freedom enhances integration through capital and logistics infrastructure, and high labor dependence reflects structural inefficiencies that limit competitiveness.

The key contribution of this research lies in linking trade dynamics with logistics and service science. By highlighting the risks of overreliance on soybeans and palm oil, the study emphasizes the importance of diversification strategies and resilient logistics corridors. The role of regional hubs such as Jeddah, Dubai, and Alexandria demonstrate how infrastructure and digital monitoring can transform import dependence into opportunities for value creation and re-export.

Managerially, the findings suggest that policymakers and industry leaders should combine demographic and institutional advantages with sustainable agricultural practices and technological upgrading. Promoting certified sustainable oils, enhancing multimodal logistics, and fostering coordinated BRICS policies are essential to balancing growth with ecological responsibility.

Looking ahead, future research should incorporate post-2020 data, consider climate and geopolitical disruptions, and explore intra-BRICS mechanisms such as joint reserves and harmonized sustainability standards. By aligning trade strategies with sustainability imperatives and leveraging its growing influence in global markets, BRICS has the potential to strengthen its position as a leader in sustainable agricultural trade and global food security.

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