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The Dynamic Relationship Between Apple's Supply Chain Regional Adjustments and Transaction Costs

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Abstract. In the face of deepening deglobalization, constantly raised trade barriers, and growing geopolitical risks, multinational companies are confronted with the challenge of adjusting their global supply chains under unprecedented pressure. Taking Apple Inc. as an example, this study aims to explore the influence of regional supply chain adjustment on transaction cost, and to explore how Apple achieved a 12 percentage points growth in production outside China in 2020-2023, that is, to reduce manufacturing in China and increase it in India, Vietnam, Thailand, Mexico, etc. The research methods adopted in this study are based on company reports, industry data and literature reviews, and the research focuses on the aspects of supply chain structure, policy effect, technology application and cost indicators. The results indicate that regional diversification can effectively reduce transaction cost, improve production and resist geopolitical and public health risks with the help of policy incentives and digital technology. The results of this study also indicate that multinational companies need to consider the regional supply chain strategy in combination with technological and policy factors to ensure efficient operation and competitiveness.

Keywords: Supply chain regionalization, transaction costs, policy drivers, technological innovation, and risk management.

1. Introduction

Under the background of significant changes in the world's global network, development and production, regional provision and deployment, coordination, development, enterprise development, and environmentally important strategies. In recent years, the trend of deglobalization, increased trade barriers, and rising geopolitical risks have forced companies to restructure their supply chains. As a leading company in the global technology industry, Apple has provided important lessons for other companies in its supply chain adjustment strategies. This paper discusses the basic idea of regional supply chain distribution including promoting factors of adjustment, items and influencing factors of transaction cost and further, takes Apple Inc. as an example to discuss evolution, coordination strategy and effect of supply chain configuration and further, discusses the influence of regional supply chain coordination on transaction cost. Finally, based on the above analysis, this paper puts forward the optimization way and future development trend of supply chain so as to provide support and reference for the optimization of supply chain configuration for the enterprises in global environment.

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2. Overview of supply chain regional distribution and adjustment

Supply chain regional distribution is the spatial layout of the company's global nodes, which reflects the company's global spatial layout of agility, adaptability, and collaboration. In turn, it will directly affect the company's ability to respond to market changes, the flexibility of the company in an uncertain environment, and the degree of collaboration between links. Therefore, a reasonable regional layout will not only affect the operating efficiency of the enterprise, but also the effectiveness of the strategic decision [1,2].

The adjustment of supply chain regional distribution is mainly influenced by three factors: cost optimization, risk hedging, and policy incentives. Among them, the transportation cost difference between different regions has a significant impact on the choice of production bases [3]. That is, the cost of transporting goods between different regions is significantly different, which will lead the company to choose different production bases. For example, in recent years, the price of transporting a 40-foot container of electronic components from China to the United States has been around $3,200-$3,750 on average, while the price of transporting similar goods from Vietnam to the United States West Coast was reported to be about $2,457 per container at the beginning of 2025. In addition, political and geographical risks, natural disasters, and even global public health events may also force companies to spread their production locations to enhance supply chain flexibility. At this time, policy incentives such as production subsidies or tax benefits will further motivate companies to expand production in specific regions. For example, even if the local labor productivity is lower than traditional production centers, companies will further motivate manufacturing in certain regions. Transaction cost includes search and information cost, contracting cost, monitoring and enforcement cost, and switching cost.

In addition, the influencing factors include geographical distance, transportation cost, and policy uncertainty. To solve these problems, enterprises can reduce monitoring and defect-related costs by investing in technology, such as using blockchain-based quality control and using AI-based supply chain management platform, so as to show the relationship between transaction cost management and regionalized supply chain design.

3. Evolution and practice of global supply chain layout

3.1. Core structure of Apple's supply chain

As shown in the following diagram, Apple has established a global supply chain system with global sourcing, regional manufacturing and centralized research and development (R&D) [4]. In this chain, headquarters in the US is responsible for R&D and overall planning; its supplier network consists of hundreds of companies. In fiscal year 2023, the company publicly released information that its supplier list covers about 98% of its direct spending [5]. Although the company has been actively expanding its production capacity in countries like India and Vietnam in recent years, China is still one of the largest manufacturing and assembly bases of the company, with about 158 partner suppliers and factories in mainland China. Meanwhile, in order to produce more in more regions around the world, the company is expanding its supplier base in Vietnam and other regions by about 8 per year, and the total number of suppliers reached 35 in 2023, rather than concentrating in one country. Although the migration trend is very clear, the high-end manufacturing links such as printed circuit boards, high-precision machining and some components are still concentrated in China and other manufacturing strong economies.

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3.2. Evolution of Apple's regional supply chain distribution

From 2018 to 2024, the layout of Apple's supply chain clearly presented the trend of regional decentralization. By expanding production from one country to multiple regions, in addition to reducing logistics costs and tariffs, it also reduced the impact of logistics and tariffs on geopolitical risks, natural disasters and global public health events [5].

India is an important growth area for the production of Apple's iPhones. According to publicly available information, the output of India's assembly of iPhones is about $14 billion in fiscal year 2024, accounting for about 14% of the global production. The growth of India's assembly output of iPhones is due to the Indian government's production incentive policies and low labor costs, and its significant export potential allows companies to reduce transaction costs in their global expansion. Vietnam is the main assembly link for lightweight electronic products, the number of suppliers in Vietnam increased from 27 in 2022 to 35 in 2023. It is expected to have about 65% of AirPods production capacity and about 20% of iPad and Apple Watch production capacity in 2025. Supplier clustering in Vietnam not only improves production efficiency but also enhances the ability of supply chains to respond quickly to market changes. Although it is expanding to more regions overseas, China still holds a dominant position in high-end manufacturing and supplying key components. From the list of Apple's suppliers in fiscal year 2023, it can be seen that about 98% of the global direct manufacturing expenditure are covered by suppliers on the list. Suppliers in mainland China are still the majority. This information shows that the regionalization of Apple's supply chain is not a complete replacement of China, but an optimization of global production through expanding to more regions.

3.3. Supply chain adjustment strategies and outcomes

In the face of uncertainties such as trade frictions, policy, and the global public health pandemic, Apple spread its production across multiple regions to reduce supply chain risks [6]. By dispersing its production bases, in addition to enhancing the resilience of its supply chains, the company also prepared for a buffer for the long term. Although there was an increase in costs in the early stages, such as an increase in supplier certification fees, employee training periods in Indian factories were about 25% longer than in China, and cross-border logistics costs were about 18% higher, these costs in the early stages have prepared for later stability and cost reduction.

In terms of concrete results, the supply chain risk coefficient of Apple has decreased from 0.58 to 0.35, and the cumulative tariff savings reached about $9.5 billion. Due to the maturity of regional clusters, the "J-shaped curve" phenomenon is presented. For example, the degree of concentration of suppliers in Bac Ninh province, Vietnam, is very high, and the localization degree of AirPods components reached 85%, and the turnover rate of inventory was about 7.8 times per year. Besides, digital twin technology and AI-based supply chain control towers have greatly improved the accuracy of production line configuration and speed up the decision-making speed. The production line configuration costs decreased by about 25%, and the decision-making cycle decreased by about 35%. From the above adjustments, it can be seen that by adjusting production bases in different regions, applying advanced technologies, and optimizing production processes, companies can improve both flexibility and efficiency in their supply chains in the face of external shocks. That is, facing the external environment, companies can reduce transaction costs through strategic investment and tool application, and also allow global supply chains to respond flexibly to changes in policies and markets, thereby providing support for companies' long-term competitiveness.

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4. Impact of supply chain regional adjustments on transaction costs

4.1. Relationship between cost changes and regional layout

Adjustments in the regional layout of the supply chain affect the company's cost structure. There are significant differences among regions in terms of logistics, tariffs, and cost or efficiency, so companies take both cost and efficiency into account when choosing production bases [7]. For example, different costs from China, Vietnam, and India to the United States force companies to adjust their global production networks to reduce logistics costs and make the supply chain more responsive.

From a mechanistic perspective, the decentralization of regional production not only takes advantage of the cost advantages of different regions, but optimizes inventory and transportation routes, reducing the impact of long-distance transportation on capital locked in and transportation delays. In addition, when companies produce in low-cost regions, they can reduce the unit product cost through economies of scale procurement and localize products through production efficiency, thereby improving unit product costs through cost-location interaction. Geographical distribution of the supply chain is not only a way of risk management, but also an important way for companies to reduce costs and improve efficiency.

4.2. Influence of policy environment and compliance costs

Supply chain decisions are greatly influenced by the policy environment. Generally, institutional factors such as tariffs, subsidies, and environmental policies have not only affected the production cost structure, but also the regional layout of companies [8]. Section 45X of the U.S. Inflation Reduction Act and the tariff arrangement of the EU-Vietnam Free Trade Agreement (EVFTA) directly prompted companies to adjust their production capacity in global supply chains to reduce the impact of tariffs.

From a specific mechanism perspective, in addition to the administrative cost or operational cost brought about by policy compliance, such as the reporting and certification fee paid by companies under the Carbon Frontier Adjustment Mechanism (CBAM), there are also indirect benefits, such as the improvement of the company's low-carbon image and improvement of product pricing power. According to the Boston Consulting Group's analysis in 2023, policy factors made up about 44% of supply chain decisions, which was higher than cost factors (38%) and risk factors (18%), indicating that companies are also very sensitive to institutional constraints and incentives in their global operations. This analysis shows that in addition to affecting the geographical location and cost control of the supply chain, the policy environment has also become an important factor that prompts multinational corporations to optimize their supply chains through brand value, market access, and long-term strategic benefits.

4.3. Role of production efficiency and technological optimization

Supply chain productivity and technology application can affect a company's costs and operational performance. Labor costs and efficiency vary significantly among different regions [9]. The efficiency of factories in India is about 75% of that in China, and this efficiency difference prompts companies to make corresponding optimization in layout and process. In terms of technological optimization, through the use of blockchain technology, application of artificial intelligence and

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digital twin technology, the whole monitoring and conversion cost becomes much cheaper and production efficiency greatly enhanced.

For instance, the “eco-park” in Bangalore, India, compressed 17 key suppliers into a 50-km range, logistics coordination cost reduced by about 25 cents through spatial clustering of supply chain nodes. Additionally, by using digital twin technology, the whole configuration of production line can be optimized and artificial intelligence platform helps to accelerate decision-making process, so companies can respond rapidly to customers’ demand from various regions. Through the integration of regional layout and technology application, the whole cost, efficiency and inventory can be optimized and even the resiliency of supply chain can be enhanced. The competitiveness of the company will be improved accordingly.

5. Optimization paths and future development

Cost trade-offs and policy factors are necessary for optimal supply chain optimization [10]. When companies start to adjust their supply chains, the transaction cost will increase. However, with the development of regional clusters, transaction costs will be greatly reduced. Policy factors influence the decision-making process more than traditional costs, which greatly outweighs labor costs, and multi-regional deployment can mitigate geopolitical shock and public health events.

From a strategic perspective, in the future, supply chains will tend to be “Glocal” chains integrated globally but operated regionally. Companies can avoid technological reliance on a single supplier and adopt alternative technologies to reduce risks by adjusting the degree of agility, adaptability, and synergy (3A principle). Digital and intelligent technologies can enhance transparency and improve technology operations, thereby reducing monitoring costs and switching costs.

In terms of environmental, social, and governance (ESG) and carbon emission management, ESG and carbon emission management not only help companies achieve sustainable development goals, but also help improve the resilience of supply chains. Companies can use geopolitical quantitative analysis models and artificial intelligence algorithms to comprehensively analyze labor costs, tariff fluctuations, and logistics infrastructure to adjust global supply chain layout, thereby improving the scientificness and flexibility of decision-making.

6. Conclusion

This study demonstrates that regionalization and multi-node production can lower logistics costs and tariffs and improve supply chain resilience in face of global uncertainties. Labor efficiency, policy environment and technological level of various regions have impacts on cost and performance of enterprises, and the policy incentives, tariff arrangements and environmental requirements have significant impacts on supply chain decisions. Blockchain, artificial intelligence and digital twin not only can improve production and inventory, but also can make the supply chain more flexible and enhance its ability to cope with market fluctuations and unexpected events. In the future, effective configuration of the supply chain should focus on the coordinated use of regional distribution, policy sensitivity and technological means to reduce transaction costs, improve efficiency, and better cope with various risks such as geopolitical events and global public health events, and maintain long-term competitive advantage.

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