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From Lean to Agile-Resilient: A Study on the Evolution Path of E-commerce Supply Chains under Same-day Delivery Services — A Case Study of JD Logistics

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Abstract. With the upgrading of consumption and the increasing uncertainty of the external environment, e-commerce platforms urgently need to build a supply chain system that is both efficient and resilient. For Chinese consumers, their needs have changed from simply "being able to buy" to "buying well and buying fast". "Same-day delivery" or even "one-hour delivery" is no longer an extra value-added service, but has become a key factor in platform competition. Based on JD.com, a representative Chinese e-commerce company that has built its own logistics system, this paper studies the evolution path of its e-commerce supply chain under the background of same-day delivery service and the effects it brings. This paper focuses on the integration path of the three paradigms of "lean, agile and resilient". Under the macro background of deepening reforms and strengthening the resilience of industrial and supply chains, exploring the applicability of this e-commerce supply chain evolution in China has important practical significance.

Keywords: Lean, Lean-Agile, Agile-Resilient, Same-day Delivery E-commerce Supply Chain, JD.com

1. Introduction

In recent years, at the technical level, technologies such as the digital economy, big data, the Internet of Things and artificial intelligence have developed very fast, and traditional logistics supply chains are gradually transforming toward intelligence and digitalization. Within the e-commerce supply chain industry, traditional supply chains usually have low coordination efficiency, weak emergency response ability and low inventory turnover, which makes them difficult to adapt to rapid market changes.

At the same time, as consumers' requirements for delivery speed and service quality have increased significantly, together with the upgrading of e-commerce consumption and the uncertainty of the external environment, the traditional logistics model that focuses only on "efficiency first" is being abandoned, which has become an inevitable trend of development. Supply chain upgrading

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and transformation has become the core competitiveness of logistics companies. Intelligent management, digital warehousing and visual tracking are now the main goals pursued by the industry. Major logistics enterprises are gradually shifting from a "single delivery model" to an "integrated supply chain service" model. Therefore, how to build a supply chain system that is both agile and anti-fragile has become a common issue for both academia and industry. Under this background, fast-response services such as "same-day delivery" have become a key competitive barrier for e-commerce and retail enterprises.

After the pandemic period, JD.com's intelligent procurement platform played an important role. It not only helped many industrial enterprises recover, but also highlighted JD.com's outstanding performance, which reflects the effective transformation path of its supply chain [1]. In order to achieve agile business response and efficient operation, JD.com has established long-term cooperative relationships with upstream suppliers, and further built its own dedicated logistics system to provide strong support [2].

As a representative enterprise of integrated supply chain logistics services in China, JD Logistics has typical research value and demonstration significance in its supply chain upgrading practices. Since the establishment of JD Logistics, it has taken "technology-driven" development as its core, and has taken the lead in layout in key fields such as intelligent warehousing and unmanned delivery. At the same time, it has built a full-chain service system covering warehousing, transportation, distribution, customer service and after-sales service. Relying on the advantages of its self-operated logistics network, JD Logistics shows strong competitiveness in order fulfillment timeliness and refined inventory management.

This paper takes JD's e-commerce supply chain as the research object. Based on supply chain strategic fit theory and evolution theory, it discusses and analyzes the challenges faced by JD Logistics' half-day delivery supply chain, and focuses on the integration path of the three paradigms of "lean, agile and resilient". Through the JD Logistics case, this paper systematically analyzes the strategic transformation mechanism of high-timeliness e-commerce supply chains, and explores the whole development and innovation process of JD Logistics, as well as the supply chain structures and operation models that can be learned and referenced.

2. About JD Logistics

2.1. JD Logistics' development positioning and its "lean-agile-resilient" evolutionary journey

JD Logistics is one of the leading technology-driven supply chain solution and logistics service providers in China, and it mainly focuses on integrated supply chain services. In recent years, it has mainly relied on digital and intelligent technologies and six coordinated logistics networks to provide customers with more diversified solutions, so as to help improve inventory management and reduce operating costs.

As one of the leading companies in the logistics industry in China and even in the world, JD Logistics is a typical example of a technology-developed integrated supply chain. Since 2007, JD Group made the decision to build its own logistics system. In 2017, with the development of some technologies, the logistics business was separated and operated independently. In 2021, JD Logistics was listed in Hong Kong. Its core mission is "to achieve efficient circulation through supply chain infrastructure and technological innovation".

In terms of supply chain development, JD Logistics has achieved a gradual evolution, from "integrated warehousing and distribution", to "end-to-end supply chain services", and then to focusing on ultra-fast delivery services such as "half-day delivery". Through the continuous

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improvement and innovation of technology, JD Logistics brings consumers a more extreme and more satisfying service experience.

2.2. Jd.com's industry position and social value

In the field of supply chains, JD holds a leading position in the industry. Its logistics business ranks among the top 30 global logistics companies, and it is also the second largest logistics brand in the world. At the same time, JD Industrial is one of the largest MRO procurement service providers in China. As a large e-commerce company, JD mainly consists of an online retail platform and a self-operated logistics company. Its key feature lies in the self-built logistics model adopted by JD Logistics, which is also the core difference between JD and other e-commerce platforms. Under this model, all logistics functions, including transportation, packaging, warehousing, loading and unloading, circulation processing, and information processing, are fully incorporated into JD's own service system. This enables JD to achieve independent operation and control over the entire logistics chain [3].

JD also has diverse and long-term social value. By building the first packaging laboratory in the industry that covers the whole supply chain from upstream to downstream, JD has achieved obvious results in the field of green packaging. It has not only promoted the use of more than 20 million biodegradable packaging materials, but also successfully reduced more than 1 billion cases of secondary packaging, which shows its leading role in the low-carbon transformation of the supply chain [4]. In addition, JD has built a global fulfillment network, which provides strong support for the global expansion of Chinese brands and the development of the dual-circulation pattern.

3. Challenges faced by JD Logistics' half day supply chain (external)

3.1. Instant demand and increased volatility: more concentrated peak pressure

First of all, the demand side is increasingly pursuing "immediate needs". Orders fluctuate greatly, consumers are more concerned about the speed of delivery, and orders are easy to pile up in a short time. The external factors, such as promotional activities, weather conditions and hot events, are more severe. The half day operation time is pressed very short. The system processing peak orders is not only a matter of "how much can be handled", but also a matter of rhythm "done in a fixed batch". If the selection, delivery or distribution of goods in the front is slower, the delivery process in the back may not catch up with the delivery batch, and the orders in the back will follow the timeout. In fact, the coverage area and service time of the same day service often change with time, and the high timeliness commitment has to constantly adjust and find a balance in the external fluctuations [5].

3.2. Industry competition and cost squeeze: faster commitment brings higher unit cost

The second external challenge comes from the "benchmarking effect" of industry competition. With the popularity of intra city and near-field distribution, timeliness is often used as a dominant selling point between platforms, and service commitments continue to move forward. In order to achieve "faster" in half a day, it needs more intensive front-end capacity, more high-frequency scheduling and more sufficient flexible transport capacity. These inputs do not necessarily bring equal proportion of income increase. Price competition and subsidy strategies are superimposed, and enterprises are under the dual pressure of "timeliness improvement" and "cost control". Demand

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disturbance and the organization of terminal capacity directly affect the cost and stability. The stronger the elasticity, the higher the management complexity and uncertainty [6].

3.3. Urban end constraints: traffic right of way and community governance improve uncertainty

The third challenge comes from the constraints of the urban end environment. Half day terminal delivery depends on external conditions, traffic congestion, temporary control, access control rules for office buildings and communities, parking and upstairs restrictions, etc. these factors widen the gap between "theoretical timeliness" and "actual timeliness", and also promise to perform differently in different regions and different time periods. The supply of terminal transport capacity is affected by seasonal weather and labor market, and the supply fluctuation at peak hours is transformed into delivery backlog. Relevant studies have pointed out that there are visible cost pressures and "hidden risk barriers" synergy friction, sudden constraints and risk exposure at the end of e-commerce, and these problems have become apparent in the high timeliness mode [7].

3.4. Disturbance normalization: chain delay and recovery problems caused by extreme events

The fourth external challenge is that interference events become more frequent and have a larger scope of influence. Extreme weather, public health events, regional management and control or major activities may change the demand structure, transportation capacity and smooth traffic at the same time. There is almost no "catch-up" time buffer for half day arrival. If a node in the link is interrupted or delayed, it is more likely to have a chain reaction: there are too many cargo piles in the warehouse, the waves are disordered, the connection of trunk and branch lines has to be rearranged, and the terminal delivery has been overtime. The case study during the epidemic shows that the maintenance service can always be carried out, often relying on the ability of cross node cooperation, rapid deployment and emergency response, and simply relying on a certain link to accelerate the speed is not enough [8].

3.5. Compliance and social constraints: green and safety requirements form the boundary of high efficiency mode

The fifth challenge is policy and social constraints. Efficient delivery means more frequent delivery, more intensive vehicle and rider activities, and more complex real-time scheduling. This will bring external impacts such as traffic safety, noise disturbing residents, packaging consumption and carbon emissions. With stricter regulation and higher social expectations, enterprises should not only be "faster", but also improve their operation methods in green compliance and public governance rules. Different cities and communities have different requirements for delivery tools, delivery time and traffic rules, which will increase the difficulty of standardized operation and the management complexity and uncertainty of half day delivery [7].

4. JD Logistics' evolution from lean to agile resilience

The evolution of JD Logistics' supply chain signifies a staged progression of building capabilities that can dynamically align with market conditions, technological capabilities, and corporate strategy. Evolution journey manifests the marked transition of the "Lean" vision that pay more attention to internal operational efficiency than to the responsiveness to markets, to the "Agile-Lean" vision that balances internal operational efficiency with responsiveness to markets, and finally, the integrated

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"Resilient-Agile" paradigm being the most advanced level of the supply chain characterized by high shock resistance and rapid recovery capabilities [8].

4.1. Foundation in lean efficiency: establishing reliability and core operational effectiveness through "integrated warehousing and distribution" (2007–2016)

However, at the beginning of online retail, the third-party logistics services (3PLs) were unstable, expensive, unfriendly to consumers. Not only were such inefficiencies stifling growth of e-commerce, but they also showed the most essential items that needed improvement in the business sector. To fix these problems, JD.com took a big leap in 2007 and created its own unique and complementary logistics network.

Key concerns for this stage were creating reliable fulfillment functions using vertical integration and process standardization, with "lean" at the heart of everything. JD.com quickly spread the goods to be closer to consumer markets by the use of state-of-the-art warehousing cente spread these goods around the country to the consumer markets by way of excellent warehousing centre such as the "Asia No.1" in the country. Besides drastically reducing delivery distances, this also made it possible to do very strict and standard checks in all the phases of the operations, thus obtaining a very good quality.

Such a centralised inventory plan, which implies exchanging space for time—to have a manageable logistics network—and what enabled people to exercise complete control over timeliness fulfilment and costs. Not only does this process boost the speed of delivery and service quality, it also alters customers' expectations of"real products with fast logistics"and reinforces their brands' memory. In addition, by bulk buying and perhaps making process simplifications, always reducing the average cost for a single order, improving its internal efficiency and cost control.

In this way, JD is paving the way for its own expansion while providing a distinctive template for the industry's progress.

4.2. Smart evolution: infusing data-driven agility and networked open collaboration (2017–2020)

When the e-commerce market reaches maturity and the demand of different products and time characters of customers continue to rise and become more immediately timely, the variations of daily sales hit new heights and place higher requirements on the flexibility of supply chain. Although fixed networks and plan-driven lean modes have advantages, they turn out to be too rigid to respond to sudden, unexpected changes in demand. JD Logistics' independent operation in 2017, to a certain degree, raised its strategic level to become a "technology-driven open supply chain service provider". This was a transition from the "lean" paradigm to the "agile-lean" paradigm—hence, increasing systematically the agility of the system as a response to a change of the market while preserving the level of efficiency. The transition is dependent on two aspects: technological openness and network openness. On a technological level, large-scale application of big data, artificial intelligence, and operations research algorithms has made it possible to develop intelligent forecast, warehousing and route-optimization systems. The change from experience-based to data-driven real-time dynamic planning greatly contributes to the improvement of inventory turnover and operational precision [9].

Networking changes are from closed, self-operated systems to open, collaborative networks. By designing a multi-level distributed network architecture "central warehouse—front-end warehouse—end point station" and embedding inventory deeply into communities, it can provide such feasible

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and reliable physical support to "same-day / hour delivery" [1]. For instance, opening up the logistics system to third parties also enables using the external complex scenario feedback system to enhance resilience and adaptability. The core achievement of this stage is to be able to react quickly to market changes but at the same time remaining low on costs, high on efficiency, at least.

4.3. Resilience-agility synergy: systematically embedding resilience to address uncertainty shocks (2021–present)

Severe disruptions to e-commerce logistics during a global emergency such as the COVID-19 pandemic have highlighted that even the most effective and responsive supply chains become impotent if they face systemic and widespread force majeure events. For extreme cases such as a logistics disruption, drastic demand changes and material shortages, supply chains need more resilience, flexibility and ability to recover quickly. With this, JD Logistics made an even more definitive declaration in 2021 of building a "Resilient-Agile Supply Chain," another momentous strategic step. This paradigm requires "resilience" to be deeply embedded in the "precise" and "agile" fundamentals, so that a supply chain can respond quickly to the market call not only but also survive the major shocks and to recuperate quickly [8].

In practice, this development is mainly carried out along three main lines. The first is network redundancy and distributed design. By building a multi-level and replaceable distributed warehousing layout, JD avoids excessive dependence on a single node. For example, when the Asia No.1 warehouse in Wuhan was locked down due to the pandemic, the system was able to quickly start cross-warehouse allocation and divert orders to other centers, which ensured the continuous operation of the supply chain [8]. The second is intelligent coordination and emergency scheduling. Relying on systems such as the "Logistics Super Brain", JD has established dynamic emergency response and cross-regional coordination mechanisms, which can sense interruption risks in real time and automatically generate alternative solutions [9]. The third is full-chain digital resilience. By realizing end-to-end visibility from suppliers to consumers, enterprises are able to quickly locate break points, assess impacts and implement contingency plans during crises, which greatly shortens the "perception–response–recovery" cycle [10]. In addition, financial digital transformation delivers cost and cash flow support for business continuity through dynamic risk monitoring and intelligent budget adjustment [11]. At this stage, the strategic priority of JD Logistics has shifted from simply improving response speed to further ensuring system continuity, operational steadiness and enduring viability in a highly uncertain environment.

5. Summary of successful experience: analysis of key elements

5.1. Business flow determinization: ensure performance capability and shape user perception

When defining JD Logistics' lean supply chain performance capability, resource integration capability is crucial. JD Logistics uses its original concept of "integrated warehousing and distribution" to build a three-level warehousing network of "central warehouse - front warehouse - Satellite warehouse", creating a flexible warehousing and distribution ecosystem. At the same time, relying on the strategy of "Asia first", its more than 500 front-end warehouses have reached the same day. During the epidemic period, JD ensured more than 85% of the order fulfillment rate through resource allocation among warehouses [12]. In addition, JD also cooperated with other enterprises to achieve inventory coordination. At present, JD retail has about 5million self operated SKUs, and the inventory turnover days have been shortened to 34 days, showing world-class supply

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chain management capabilities. This mode of vertical integration of resources effectively reduces the uncertainty of contract performance and improves efficiency.

5.2. Intelligent data flow: refined data, technology-driven decision-making flow

Strengthen the supporting role of information technology in the construction of JD Logistics' precise and sensitive supply chain. Through cloud computing, big data, artificial intelligence, automation equipment and other technologies, jd.com has improved the agility of the supply chain while maintaining efficiency, realized the intellectualization from demand forecasting, warehousing to distribution, and driven the decision-making process. In terms of demand forecasting, JD retail conducted intelligent forecasting, automatic distribution and intelligent contract fulfillment for more than 5million commodities during the "double 11" period, and the sales growth rate of 13532 key brands exceeded 300%. In the aspect of warehousing, jd.com has built the "Asia's first" intelligent logistics park with 5g technology, which is widely applied with CNC PLC, robots and intelligent systems. The sorting efficiency of the park is five times higher than that of the traditional operation mode, and the average daily order processing volume can reach one million orders, providing users with a highly efficient and intelligent warehousing system. In the distribution link, jd.com integrates artificial intelligence and other technologies to create an intelligent contract performance decision-making brain, which can process data in real time and predict the best path. Since jd.com launched the "survival of the fittest" project in June 2019, the scope of implementation has been extended to more than 60 cities in just one month, with more than 300 stores and 24000 stores in cooperation channels, realizing 15 minutes' rapid door-to-door delivery. The agility and efficiency of the supply chain can be improved by using technologies such as big data and artificial intelligence.

5.3. Process redesign: build an open and collaborative network, and further upgrade the emergency response mechanism

The construction of JD Logistics' resilient supply chain is based on standardized process modules, flexible reorganization mechanism, unified and perfect emergency response mechanism and high-quality development. JD Logistics has standardized the warehousing, sorting, distribution and other processes into more than 200 standardized operation modules, which can be quickly combined and switched according to the actual situation. Usually, each module runs according to the established process. However, in case of emergency, other functional modules will be temporarily borrowed for reorganization to cope with sudden pressure. Under normal circumstances, JD Logistics mainly adopts a mixed distribution mode based on independent operation and supplemented by crowdsourcing. During the "618" and "double 11" and other large-scale promotional activities, crowdsourcing has become the main source of distribution capacity, taking over 60% of the last mile delivery orders. This is conducive to the reallocation of human resources within the enterprise and effectively alleviates the shortage of human resources in other processes. Reduce the operation error rate through the standardization of business processes, and enhance the flexibility of the supply chain to deal with complex situations through the rapid reorganization between modules.

5.4. Universal implications: element synergy and system effects

The successful experience of JD Logistics' half-day delivery service indicates that building an efficient, resilient and flexible supply chain system requires simultaneous attention to the systematization of business, technology and network, and emphasizes the synergy among elements.

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For other e-commerce logistics firms, the three-stage path of "determination of fulfillment capacity, digital support, and collaborative operation" can be referred to: First and foremost, create a stable and controllable warehousing and distribution ecosystem; second, deploy and upgrade intelligent infrastructure; and finally, the integration of standardization and flexibility has improved the emergency response mechanism, resulting in high-quality and rapid response. Furthermore, this paradigm applies not just to high-efficiency scenarios like half-day delivery, but it also provides a referenceable methodology for supply chain optimization in domains such as community group purchasing and cold chain management.

6. Conclusion

This study takes JD Logistics' half-day delivery as a case to systematically analyze the evolution path of its e-commerce supply chain, and investigates the external challenges, transformation paths and success factors faced by the logistics supply chain. Research has found that JD Logistics has achieved a systematic transformation from a lean supply chain to a resilient and sensitive one in response to external challenges such as peak order volumes, immediate demands, the "benchmarking effect" of industry competition, and constraints from the terminal environment through three major measures: determining business flow control power, promoting decision-making through digital intelligence, and reconstructing and evolving emergency mechanisms through an open and collaborative network. The key to its success lies in laying the foundation of intelligent technology, building a controllable warehouse network ecosystem and an open collaborative system, evolving the dynamic reconfigurability of the emergency mechanism, being able to analyze pre-event plans in real time, and effectively enhancing the response speed, elastic scheduling and risk resistance of the supply chain.

The theoretical contribution of this paper is mainly reflected in the proposal of a three-dimensional collaborative analytical framework of "business - technology - network", which provides a systematic and clear logic for subsequent research. At the same time, it expands the application of the resilient supply chain theory in the e-commerce logistics scenario and verifies that in a highly uncertain environment, the new "data-driven resilience" has more advantages than the traditional "inventory buffering resilience".

The experience of JD Logistics also provides the industry with referenceable implementation inspirations and paths: enterprises should build a controllable warehouse network ecosystem and an open collaborative system, promote intelligent transformation, construct an elastic and scalable logistics network, and evolve emergency response capabilities.

However, this study still has certain limitations: First, it is mainly based on the public information and secondary data of enterprises, lacking internal data of enterprises. Second, there are not enough horizontal comparison objects. No multi-case comparative analysis of JD.com with SF Express, Meituan and other enterprises has been carried out.

Future research can be carried out in the following directions: reaching academic cooperation with enterprises, obtaining internal data and conducting joint research. Or broaden the horizontal comparison and start to study resilient supply chains from enterprises of different scales and types. With the continuous deepening of the digitalization of logistics, how to build a supply chain system that strikes a balance among "efficiency, flexibility and sustainability" will become an important issue of common concern in both academia and industry.

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Authors contribution

All the authors contributed equally and their names were listed in alphabetical order.

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