

## THE EVOLUTION OF SUPPLY CHAIN MANAGEMENT

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### ABSTRACT

When analyzing the traditional supply chain, enterprise autonomy is not taken into consideration. In contrast to evolutionary game theory, CAS was used in this paper to investigate the dynamic growth of the supply chain. The Development of the Supply Chain Management Idea provides a summary of the viewpoints on supply chain management. The Company was thought of as a supply chain middleman. In a similar vein, all of the company's locations were treated as subagents. The agent-based supply chain model was first introduced in this work. Simultaneously, swarm intelligence was used to simulate the supply chain's dynamic expansion. Also looked at was the optimal method for coordinating the actions of the main supply chain participants. In addition to providing a system for supply chain administration, this paper explores the evolutionary traits of supply networks.

**Keywords:** supply chain system; complex adaptive system; evolutionary game theory; swarm simulation platform

### INTRODUCTION

In response to many causes, such as shifting company dynamics, technology improvements, globalization, and rising consumer expectations, supply chain management (SCM) has dramatically changed over time. The origins of supply chain management may be found in early ideas and practices of management that tried to synchronize the production and delivery of goods. Influential thinkers like Frederick Winslow Taylor presented scientific management ideas in the late 19th and early 20th centuries, emphasizing the increase of production and efficiency via standardized procedures and division of labor. By focusing on organized planning and coordination inside enterprises, this strategy created the foundation for the growth of supply chain management.

The development of supply chain management was further influenced by the introduction of mass production and the assembly line, which were made famous by Henry Ford's Model T manufacturing. By introducing the idea of interchangeable components and vertical integration, Fordism revolutionized manufacturing by allowing businesses to attain economies of scale and mass manufacture standardized items. The coordination of the flow of supplies and information as well as managing intricate manufacturing processes were both made difficult by this method. Physical distribution management was created in the years after World War II in response to the increasing complexity of supply networks. Companies realized they needed effective transportation, storage, and inventory management to deliver goods to consumers on schedule as a result of the development of consumerism and greater competition. During this time, ideas like order fulfillment, transportation planning, and warehouse efficiency became more popular.

A crucial turning point in supply chain management was the introduction of Just-in-Time (JIT) concepts by the Toyota Production System in the 1970s. JIT placed a strong emphasis on minimizing inventory levels, cutting waste, and working closely with suppliers and manufacturers to ensure smooth production and delivery. Worldwide supply chain management strategies have been impacted by JIT's effectiveness in increasing productivity and lowering costs. In the latter half of the 20th century, supply chain management witnessed more changes. Enterprise resource planning (ERP) systems, which have been widely used, have made it possible for businesses to collect and analyze data, increase supply chain visibility, and coordinate efforts among many stakeholders. Real-time tracking, inventory management, demand forecasting, and order processing were made possible by the integration of information technology into supply chain activities.

Supply chains have been increasingly internationalized in recent years as a result of globalization, calling for a more comprehensive and internationally integrated approach to supply chain management. A new set of difficulties has emerged as a result of the growth of e-commerce and omni-channel retailing, including the need to manage several sales channels and satisfy rising

consumer demands for ease, quickness, and personalization. In addition, sustainability has become a crucial issue, inspiring businesses to embrace green supply chain strategies and lessen their environmental impact. Overall, historical changes, technical breakthroughs, shifting consumer expectations, and global business trends have all influenced the development of supply chain management. For enterprises to successfully respond to the demands of a competitive marketplace and adapt to the complex and dynamic nature of contemporary supply chains, it is essential to understand this development.

### **LITERATURE REVIEW**

**Singh, J. et.al (2017).**The supply chain management trends that have recently emerged in conjunction with new I.T. services are the main topic of this article. In order to establish a cohesive connection between suppliers, manufacturers, distributors, and consumers, supply chain management has grown throughout time. A competitive environment has been established between the sectors as a result of development in the supply chain management industry. Therefore, a full understanding of evolving technologies in supply chain management is required in order to compete in this market. We'll talk about the more general features of supply chain management and how IT services have opened doors by improving customer services and providing a competitive advantage.

**Sindi, Safaa et.al (2017)**While the evolution from physical distribution management through logistics to the current day's supply chain models is certainly not new, it has gained momentum and complexity only in recent years. This study looks at the evolution of supply chain modeling and its current status, with a focus on how technology and globalization have affected the field. Strategic supply network projections and implementation are discussed beforehand to set the stage for an analysis of the primary factor influencing the growth of a company's strategic supply chain model selection process.

**Parkhi, Shilpa. (2015).**Supply chain management is an approach for enhancing corporate operations so they are more competitive, robust, and agile. According to Machowiak (2012), SCM's main objective is to boost a service's or product's ability to compete in the market. The purpose of this paper is to examine, grasp, and explain the evolution of supply chain management. We've done some serious reading to find out what the future of the supply chain holds. We have included additional SCM definitions provided by experts over the last several decades, in addition to the essential classical definitions. Many components of the supply chain are considered in this study. The article examines Supply Chain Management and its components in order to set it apart from related disciplines such as Logistics Management, Value Chain Management, and Operations Management. The study also explains different SCM ideas. The report concludes with a conclusion and recommendations for further research after completing a comprehensive literature evaluation.

**Lu, Lauren et.al (2015).**Supply chain management is crucial to the success of any business. In this essay, we will review the recent advances in the field of supply chain management. In the first section, we define supply chain management in a variety of ways and highlight some of the key issues in this field. The difficulties of supply-chain management are then discussed. The massive inefficiencies in supply chain management are then discussed. In conclusion, we present an overview of ongoing research initiatives and a discussion of looming challenges in supply chain management.

**Maccarthy, Bart et.al (2016).**Purpose In terms of their length, structure, configuration, and management, supply chains vary throughout time. Some supply networks are established and seldom ever change. Some are subject to substantial alteration. For a number of reasons, new supply chains may develop. This essay aims to answer the question, "What makes a supply chain like it is?" by analyzing the development of supply chains and their nature. These factors interact and may have an impact on a supply chain throughout its lifespan. Emergent themes and hypotheses on the variables influencing a supply chain's features throughout the course of its lifespan are given. The article makes the case that a fresh approach to research is required to study and comprehend the supply chain lifecycle. Real-world applications Supply networks are crucial to the global economy and to daily living in the contemporary world. New views for modern supply chain design and management may be gained by understanding the lifetime of a supply chain and how it changes over time. Originality/value Leading scholars' in-depth analyses, critiques, and reflections on new, developing, and established supply chains are presented in this publication.

**EVOLUTION OF SUPPLY CHAIN MANAGEMENT CONCEPT**

**TABLE NO.1 STEPS OF EVOLUTION OF SUPPLY CHAIN MANAGEMENT**

Year 1950- 1960	<ul style="list-style-type: none"> <li>• Concept and strategic of mass production to minimize unit production cost.</li> <li>• Little Product and process flexibility.</li> <li>• Physical distribution concept for finished goods.</li> </ul>
Year 1970-1980	<ul style="list-style-type: none"> <li>• MRP(Development) Material requirement</li> <li>• Planning, sales, management, warehouse, TR and distribution Integrated operations i.e. procurement up to finished product.</li> <li>• Realization of WIP inventory impact, on</li> </ul>
	manufacturing cost, quality, product development
Year 1980-90	<ul style="list-style-type: none"> <li>• Concept of low cost, high quality, reliable product with greater design and flexibility</li> <li>• Use of Just in time Technique to improve manufacturing efficiency and cycle time.</li> </ul>
Year 1990 onwards	<ul style="list-style-type: none"> <li>• Max Utilization of corporate resources.</li> <li>• Effective flow of products, materials, funds, information and services through Supply Chain Management</li> </ul>

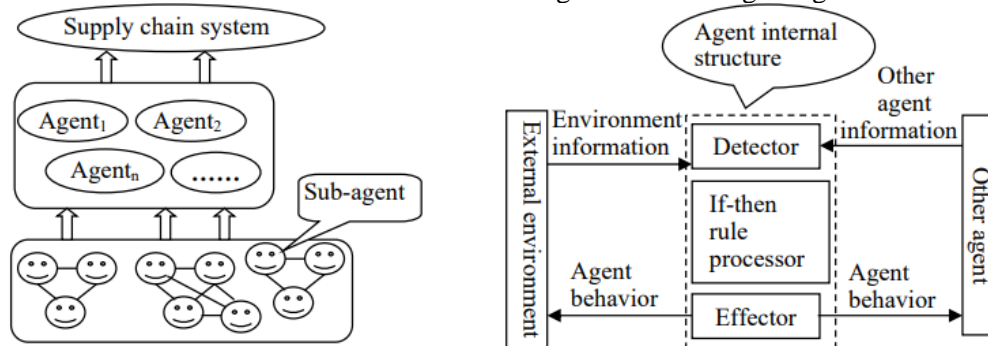
The table below provides a summary of supply chain management viewpoints.

**TABLE NO.2 SUMMARY OF SUPPLY CHAIN MANAGEMENT VIEWS**

Sr. No.	Factor	Traditional View of supply chain	Modern View of Supply Chain
1)	Tenure	Brief	Long Term and Stable
2)	Agreement	Sporadic purchase order	One purchase order in a year (open purchase order)
3)	Source/ Supplier	Many supplier for less risk and price competition	One or few
4)	Volume of Business	Low	High
5)	Design Specification	Customer developed	use of design expertise of supplier.
6)	Quality	Uncertain and Many Inspections	Quality at Sources, T.Q.M. S.Q.M; self Inspection concept (at vendors end)
7)	Delivery	In frequent and large lots	In time Delivery, small lots.
8)	Dispatch of purchase order	manual working	Modern media electronic data transfer, fax, e-mails.
9)	Delivery Locations	At Store department	Direct location at assembly point or customers end

**MODEL OF SUPPLY CHAIN SYSTEM BASED ON AGENT**

The interaction between several sub-agents in a complicated supply chain system eventually aggregated to become one agent. The complicated supply chain management system was eventually created as a result of the interactions between different agents. According to figure 1.



**FIGURE 1. ARCHITECTURE OF SUPPLY CHAIN.**  
**FIGURE 2. AGENT’S STRUCTURAL MODEL.**

• **Agent Characters of Supply Chain System**

The circumstances and behavior pattern of the agent were shown as the supply chain evolved. The agent's accumulated states determined how it behaved. The behavior of the agent directly altered the subsequent state at the same time. As a result, the agent status and behavior would create a spiral association. It was inevitable that the agent's behavior would change over the prolonged trade. This, as a result of this process, led to the agent's development, after which the system evolved. The intelligent agent in the evolution of the supply chain model has cognitive abilities such as reasoning, communication, learning, memory, preference, and intent. Each representative might adjust his trading approach in response to changes in the market and the actions of business management, according to intelligence. Each agent continuously developed during its evolution and adopted a unique management approach depending on the circumstances. Interaction acted as an agent that eventually stabilized and filtered the collaboration partner, leading to the formation of a supply chain. After the creation of a supply chain system, various businesses would change through various strategies, but what actually changed in the short term was each node business rather than the

corporation type, and in the long term, the supply chain could change as a result of the change of the corporation type.

• **Agent’s Behavior Patterns of Supply Chain**

The agent's behavior pattern inside the supply chain system was established as a reaction to the changeable import of the external environment. With the following mathematical symbols:

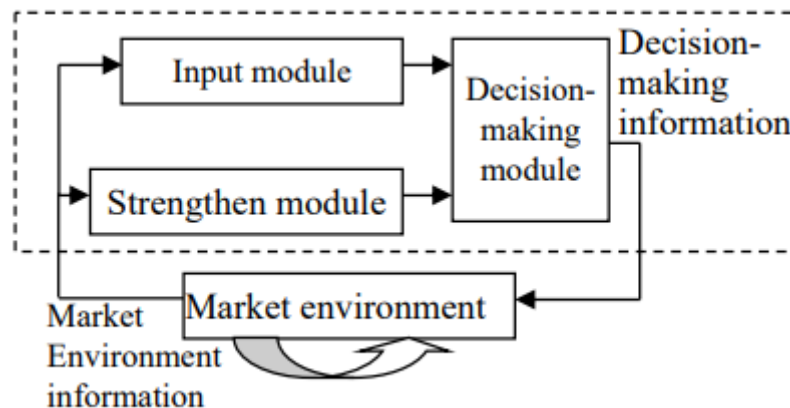
$$B = F_c(\gamma, sc_m);$$

$$\gamma \in EN = (EN_1, EN_2, EN_3, \dots, EN_m)$$

The supply chain's response to environmental stimuli was reflected in the agent's behavior patterns, or system behavior. The exterior environment of the agent was represented in the paper as the outward state set S. Among these, s (s ∈ S) represented the agent's exterior condition at a certain time. Aim represented the company aim, Eid the corporate logo, P the corporate outward information set, and I the firm itself state collection in the supply chain. Three external reaction stages—information gathering, perception, and decision—were experienced by a defined behavior state set of corporates, Infor and Action.

• **Agent’s Learning Model in Supply Chain**

Learning was an agent's apparent attribute inside the CAS. Agent's capacity to adapt was aided by his learning behavior. As the supply chain evolved, There are three distinct parts to the agent's learning architecture: input, reinforcement, and decision. Figure 3 depicts these individual components. One of these, environment information, underwent input module transformation into input information. The decision-making module then received input data. Through the strengthen module, the impact of agent activity and environmental state was converted into consistent information. The decision-making module then received the consistent information.



**Figure3. Agents’ interaction within supply chain**

**DYNAMIC EVOLUTION SIMULATION OF SUPPLY CHAIN**

Agents were abstracted in modeling and emulation to consider many levels. According to the theory, each supply chain node firm would be a CAS agent.

• **Design of Simulation**

The main idea behind emulation and layout was to build up lots of agents in a controlled context so they could carry out their tasks there. These agents were kept alive in the supply chain system and had the quality of having unique strategies and behaviors. After that, they altered themselves and outside agents as well as the surroundings. The interaction between agents was used to analyze a variety of traits and behaviors. The supplier agent handled the buy orders. In responsibility of assigning raw materials was supplier agent. A supplier's agent should participate in the design of group goods in the supply chain to speed up product development and increase design effectiveness. A supplier agent would check the nature of the raw materials. Buy orders, collaborative product design, and service management were all influenced by suppliers' agents.

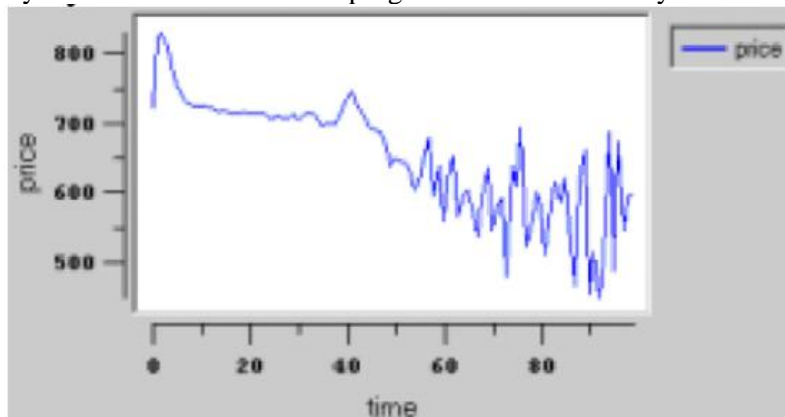
Raw resources, credibility, and long-term collaboration were among the output determinants. Production orders were received by the manufacturer agent, who then set up a production schedule and ordered production to follow it. In accordance with the raw material reserve and the order regulations, manufacturer agent issued purchase orders to supplier agent. The manufacturing representative then delivered the item to the completed products inventory. Manufacturer orders, the acquisition of raw materials, fabrication, and quality control were all inputs from the manufacturer agent. The output of the manufacturer's agent included completed goods, product pass rates, and order fulfillment rates.

- **Analysis of Simulation**

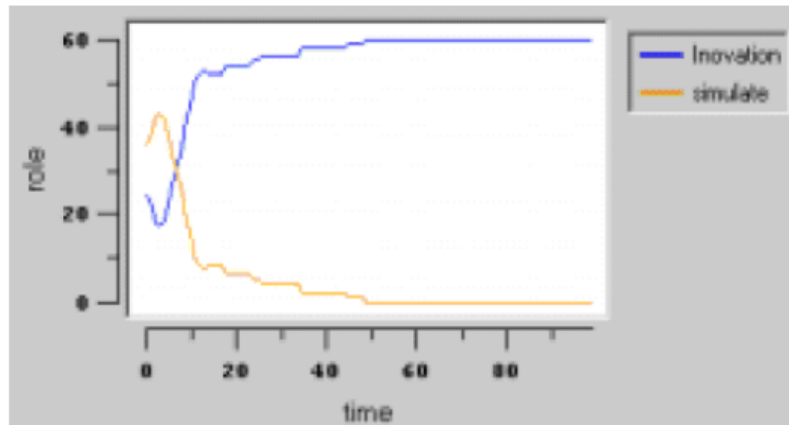
The market pricing revealed the interplay between the supply chain system's choosing strategies and the conducive environment. First, market pricing has an impact on the supply chain's return. The appropriateness of the supply chain was therefore affected by market pricing. The strategies used in supply chain management determined the market offering. Market offering would then have an impact on market pricing. In general, the supply chain's dynamic evolution was intricately intertwined with the growth potential of the macro industrial environment and the product's life cycle, in addition to reflecting changes in corporate strategy.

One time step in the simulation equaled one week's worth of time as the simulation experiment continued. As seen in figure 4, we looked into how market values changed over time. As can be seen from the market price in Figure 4, the supply chain initially selected its trading strategy at random since the agent had any prior trading expertise. Due of the exceedingly limited market offering in this situation, the market price initially seemed to be rather high. However, as market innovation experience grew, both the risk and the cost of innovation rapidly dropped. A portion of imitation agents may be tempted by the surplus profit to switch from an imitation strategy to an innovation approach.

The market price was at its maximum at this point. The imitation agent had greater room to imitate as market innovation behavior increased. The market price started to fall due to the presence of imitation agents. Because there are more imitation agents available, more products are offered and the market's price is falling fast. Market supply tended to remain consistent when the price fell to a certain level. But as the simulation went on, the market price started to fall, and some oscillations appeared. This moved the market's innovative behavior closer to maturity. The presence of the inventive agent allowed the industry as a whole to continue its progress for another 100 cycles.



**Figure 4. Market price of supply chain.**



**Figure 5. Key choice of the supply chain.**

Figure 5 shows how to choose a supply chain key. Emulation of the supply chain for innovation provided an increasing trend in the early going. As the market price rose to its greatest, the number of copycat supply chains reached its peak. Despite the poor yield of the copycat supply chain, the high market pricing nevertheless enabled him to make a significant profit. The percentage of the supply chain likewise tended to be steady when the market price was. However, the supply chain for invention took up the whole market in the simulation, representing the market's higher level of innovation.

#### **CONCLUSION**

Construction complexity, including substance connection and network composition complexity, substance behavior complexity, geographic dispersion complexity, and other entity complexities were deemed to be the primary representations of supply chain as CAS. Interactional complexity was also a product of the flow of data and capital inside each corporate entity as well as the system's openness, which principally reflected the interaction between the enterprises. In the study, the supply chain is analyzed as a complex adaptive system, and agent modeling and simulation are used to learn more about it. It was investigated how supply chains evolved. In the next study, we'll improve the agent's capacity for learning and strengthen the system's intelligence.

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