



Building A Network-Based Methodology to Model Supply Chain Systems.

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Abstract

It's important to note that supply chains are interconnected networks of suppliers, manufacturers, distributors and customers. Typical supply chains are defined by their complexity and the inherent uncertainty in their operations. Using a supply chain network's evolution model might help you better understand how it grows. Supply chain traits and attributes are frequently left out of current evolution models. "Based on external market demand and internal rivalry and cooperation, this paper provides a novel supply chain evolution model that centres on manufacturers. Evolution presupposes that the external market environment is largely steady and takes into account a number of elements, including supply chain topology, external market demand, ecological growth and conservation. Supply chain systems are modelled and analysed using network-based techniques. A supply chain is depicted as an abstracted network in the technique. It is possible to incorporate stochastic variables into the model so that the supply chain's operational uncertainty can be modelled. There are many complicated structural and behavioural features of supply chain systems that can't be successfully modelled by traditional engineering and operations management methodologies (SCSs).

Keyword

Supply Chain , SCS , Entropy , Network , IOT

Introduction

Supply chains are an essential component of our daily lives, but they are often overlooked. Managing supply chains is a complex and ever-evolving undertaking, and almost everything we buy in a store is part of one. Supply chain network architecture relies heavily on location intelligence. It's a piece of technology or software that connects users to other members of a community in order to create mutually advantageous opportunities for all parties involved. Supply chains are made up of an enormous number of businesses and their mutual partnerships, in which the businesses engage directly or indirectly with the core businesses.[1] Businesses act as nodes in this network, while their relationships with one another act as linkages. Supply chains are becoming ever more global and complicated for businesses to utilise in the production and delivery of their goods and services [Binder and Clegg, 2007; Basole and Rouse, 2008]. As a result of today's hypercompetitive business environment, organisations must constantly look for ways to reduce operational costs, deliver good customer service, and limit the risk of interruption by creating and managing efficient supply chains [2].

These supply networks are known for their intricacy and their inherent uncertainty. Given the stochastic nature of most supply chains, it is a complex and challenging research undertaking to simulate such supply chains. Because of current innovations in communications, particularly Internet technologies, that promise to bring together suppliers and customers in a single, integrated network of information, this issue is becoming more urgent. This has the potential to significantly improve decision-making and operational efficiency [3-6]. This promise, however, is contingent on the development of an appropriate supply chain modelling technique.

Material, information, and value movement are all controlled by the supply chain network seen in Fig 1, which begins with raw material procurement and continues through manufacturing, warehousing, distribution, and eventually to retail sales. Complex networks, like this one, share many of the features of other types of networks, such as huge scale, sparse connections and a tiny world. Suppliers and demanders are both involved in a supply chain network, which is characterised by the fact that it is multi-hierarchical and that each tier has a common set of businesses and services.[7]

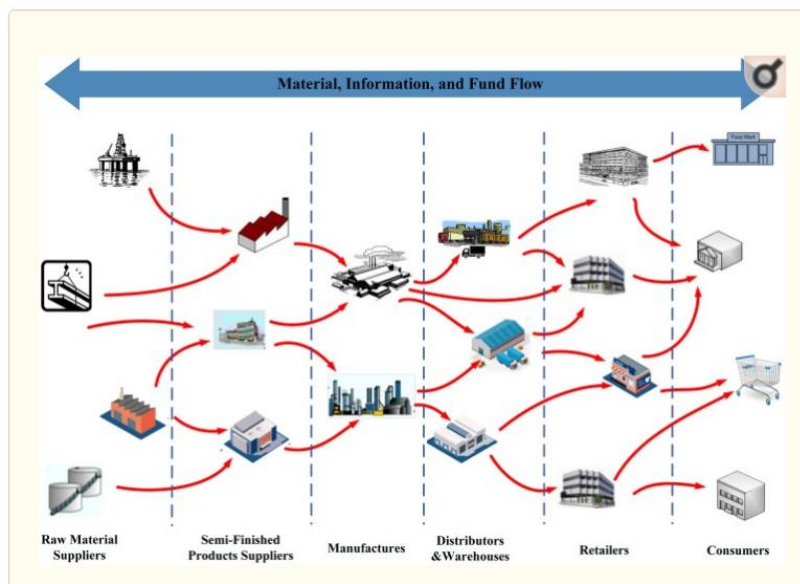


Fig.1 The schematic diagram of supply chain network, which is a network with manufactures as the core.

Adapting supply chain networks to market demand and internal competition-cooperation is a constant process. There will be an increase in the number of businesses that have a strong competitive advantage. On the other hand, weaker members of the supply chain may be eliminated and replaced by new members in order to hinder the chain's growth.[8]

The supply chain's evolution can be studied using one of two approaches currently in use. Using game theory, the first method examines the evolution of competition-cooperation in the supply chain. In the current studies, this method is only utilised to analyse supply chains with a simple structure and a small number of participants. This approach can no longer be used in today's highly interconnected supply chains. Another way to comprehend the evolution law is to develop models based on the network topology structure and supply chain's inherent property.[9-10] Based on the BA evolution model of scale-free networks, which follows the rules of preferential choice and dynamic growth, the earliest evolution model was developed. This evolution model, on the other hand, has a network structure that is very different from that of genuine supply chain networks. As a result, additional research added supply chain data to the original evolution model.

Work flow of evolution model

The flow and scale of the supply chain at time t can be calculated using information from the supply chain network and the external market demand. Then, we compute the node and edge addition and deletion probabilities based on the supply chain scale and the layer active probability. We randomly add (or remove) one node (or one edge) in the given supply chain network when the evolution circumstances are ready.[11-12] Each time a new time step is taken, the network information must be updated. If a termination condition is met, then the evolution process will continue.

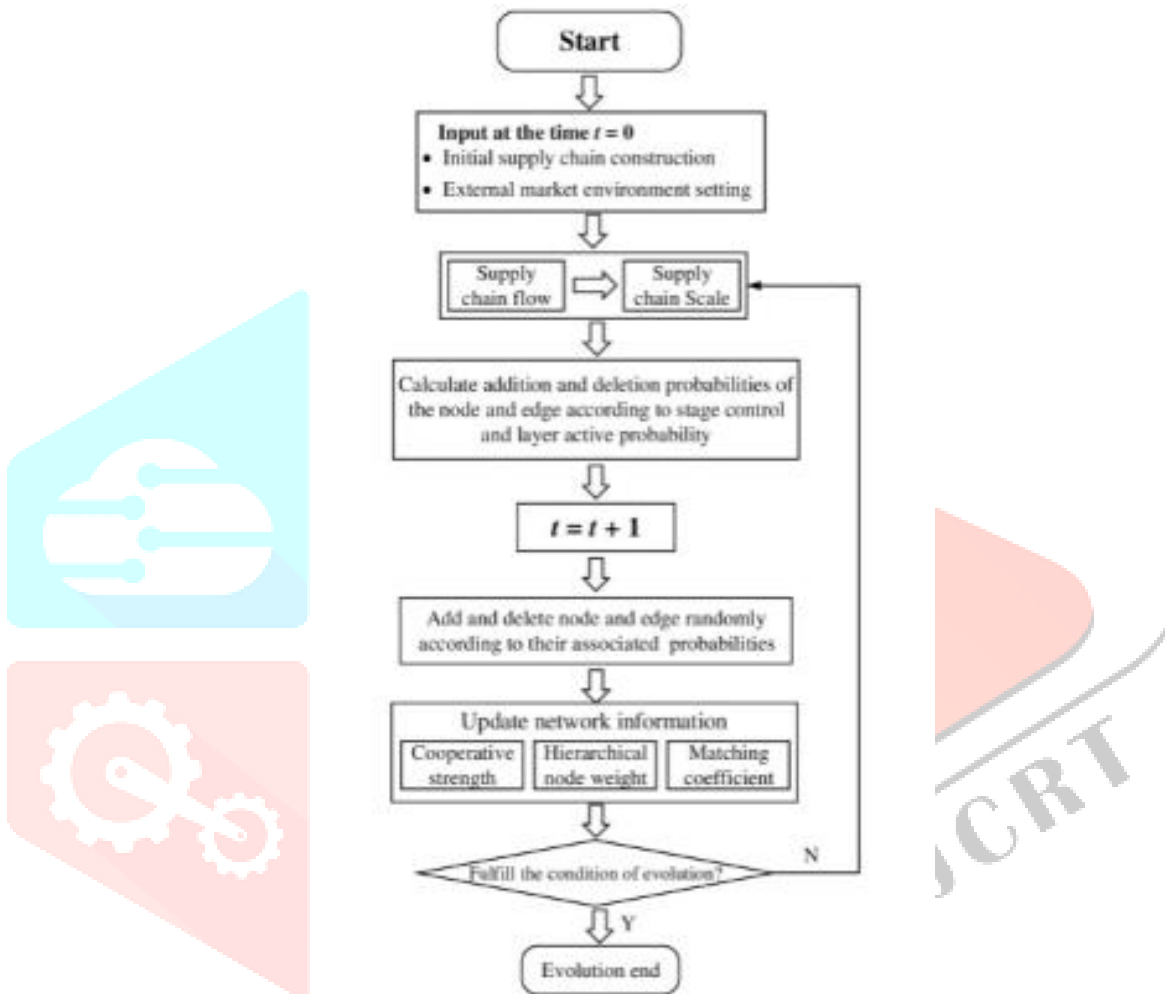


Fig.2 Work flow of evolution model

Objectives

1. Establish a framework for explaining customer consideration behaviours and for predicting future market competitions by using network-modeling techniques.
2. To comprehend the evolution of supply chain management and its various aspects.
3. Supply chain studies that use network analysis are identified and reviewed in a systematic manner.
4. These should be put together in a unified framework
5. Finally, we propose future research directions for network analysis in the design and administration of SCS and complex enterprise systems.

Review of Research

By breaking the decision-making process into two parts, Fu et al. created a two-stage bipartite network modelling approach to examine client preferences in selecting choices. Product attributes and client demographics were used by Wang et al. to forecast product co consideration relationships using dyadic network analysis.

The procurement of raw materials, conversion of these raw materials into finished and semi-finished products, and transportation of these finished and semi-finished products are all part of a supply chain's operations, workers, technological and physical infrastructures, and policies [Rouse, 2005]. The system-level features, properties, characteristics, functions, behaviour, and performance are influenced by the collection and interaction of these elements [Cloutier et al., 2010].

Technical challenges have been the primary focus of engineering and operations management modelling methodologies in the past. SCSs, on the other hand, are not well-suited to these methodologies because of the complexity of their structure and behaviour.

Network analysis uses theories from the social, organisational, and complexity sciences with graph theoretic approaches to model, analyse, and display the structure, dynamics, and strategies of SCSs. Choi and colleagues [Choi, Dooley, and Rungtusanatham; 2001;2002;2002;2009] and Borgatti & Li[2009] have sparked a new wave of studies modelling a SCS as a complex network of interactions between system elements.

According to a study by Sosa et al., it may be possible to improve the quality of complicated product designs by regulating network topology (such as hubs). Additionally, network analysis has been used to better understand organisational behaviour and improve multidisciplinary design efficiency by researching the network of designers.

Using the social exchange theory of Narasimhan and Mahapatra (2009), a customer and a supplier can better comprehend one other's lock-in circumstances. Product innovation is the process of creating a product that stands out from similar ones on the market. In the end, a specialist product will revolutionise the current market situation. In addition, the introduction of a new product frees the customer from the supplier's lock-in condition. Businesses must become more adept at picking new product winners and efficiently managing the new product process from product idea to launch, according to Cooper (1987).

Due to the increasing relevance of non-price considerations and the difficulty in deciphering the buyer's preference structure across qualities, effective bidding is a challenge for foreign suppliers. (2003), Narasimhan, et al., develop multi-attributes bidding models for effective supplier bidding tactics. Bid evaluation becomes more difficult when a company has to examine multi-product, multi-attribute bids for several products with different competitive priorities.

Research Methodology

The literature review method is employed to address the research questions. Our study aims to determine the current and future trends in supply chain management (SCM). SCM has undergone a dramatic shift in definition and theory throughout the years. We've looked at a lot of research articles and attempted to explore SCM definitions in chronological sequence.

An extensive collection of research papers from databases such as EBSCO and EBSCO was searched for. In these databases, we referred to various journals, such as International Journal of Logistics Management, International Journal of Information Management, International Journal of Physical Distribution and Logistics Management, Journal of Operations Management, Supply Chain Management: An International Journal, etc. [13-15]For the literature review, the following strategy has been used: Based on the research questions, we were able to identify the specific regions in which we needed to look for literature. After narrowing down the scope of the literature review, we conducted searches in multiple databases, such as Ebsco, Emerald, and PubMed.

Once the research papers were available, the relevant papers were sorted out based on their relevance to the study question. Papers that had been classified into categories were then assessed to see if they answered the questions.

Result and Discussion

Best Value Supply Chains

When it comes to speed, quality, pricing and flexibility, the best value supply networks employ strategic supply chain management. As important as this idea is to modern businesses, little is known about how major theories may provide light on what distinguishes these chains from others and what makes them extremely effective. Traditional and best-value supply chains are compared in this section.[16]

Theoretical perspective	Best value supply chains	Traditional supply chains
Transaction cost economics	Focus on total costs, not just transaction costs, as basic of “make or buy” decisions. Short term costs play a secondary role if the potential for long term, trusting relationships exists	Focus on transaction costs as the basis of “make or buy” decisions. Opportunism undermines trust; short term costs are a primary consideration
Agency theory	Use reward structures and cultural competitiveness to align members interests Potential for opportunism minimized	Interests of supply chain members only partially aligned Strong potential for opportunism
Resource dependence theory	Supply chain members recognize that dependence can create forbearance and trust	Each member tries to avoid becoming dependent on others and tries to make others dependent on it
Institutional theory	Use industry recipes and best practices to inform, but not dictate, supply chain management activities	Rely heavily on industry recipes and best practices to guide supply chain management activities
Game theory	Mutual dependence and trust overcome members temptation to pursue self-serving behavior	Some members use free riding, hold up, and leakage to benefit themselves and to the detriment of the chain
Network theory	A blend of strong and weak ties that matches supply chain needs is created in order to maximize supply chain performance	Strong and weak ties formed on a case-by-case basis rather than strategically
Social capital theory	Shared goals, values and experiences create shared sense making and improved performance	Mix of shared and firm-level goals, values, and experiences circumscribe shared sensemaking and limit performance
Strategic choice	Strategic decisions made with concern for the chain as the primary driver. This “strategic supply chain management” opens the door to unique blended strategies that transcend the firm	Strategic decisions made with concern for the firm as the primary driver. This approach constrains firms to using a generic strategic such as prospector or low cost leader
Resource-based view/knowledge based view	Assume that unique resources exist at the supply chain level and that supply chains can be inimitable competitive weapons	Assume that unique resources reside within firms. Supply chain management is thus a tool to complement these resources

Table 1 How different theoretical perspectives help to distinguish best value and traditional supply chains

Value Chain with a Supply Chain

"value" is employed in economics, marketing, strategy and operations in different ways, suggesting that the value chain is a misnomer, despite its widespread use. Value is a metaphysically perceived characteristic connected with the benefits that occur at various points of exchange along the resource chain, according to this approach, while resources go one way and money the other along the network of linkages between enterprises. This study concludes that value is derived from the transfer of resources and accrues to both the suppliers and the customers involved in the transaction.[17-18] Suppliers benefit from the financial resources, payment terms, stability and future order cover that their customers supply, while customers benefit from the provided products or services. Consequently, value chains run in both directions.

A Comparison of a Value Chain with a Supply Chain

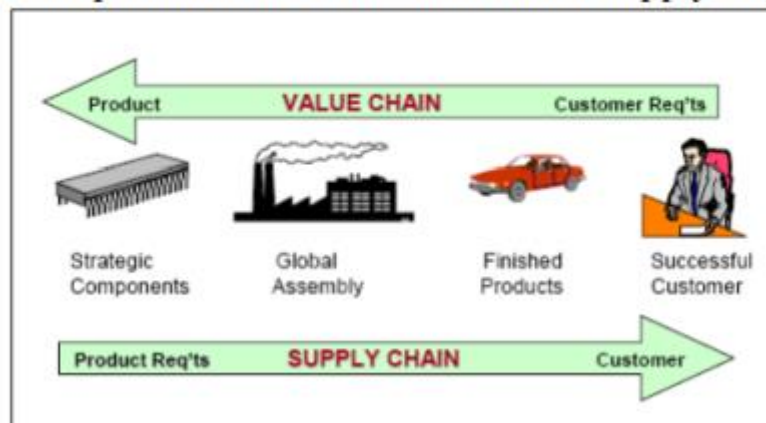


Fig.2 A Comparison of a Value Chain with a Supply Chain

Therefore, the supply and demand chains must be aligned in order to create a lucrative value chain for the company. Value chains, on the other hand, are more concerned with product creation and marketing innovation than supply networks.

As depicted in Figure 3, a supply chain's operating model consists of a supplier, an assembler, and a distributor. In this model, production is only activated when a customer placed an order for a certain product. The properties of additive manufacturing, which may be found in traditional manufacturing, were analysed in order to determine the structure.[19-21]

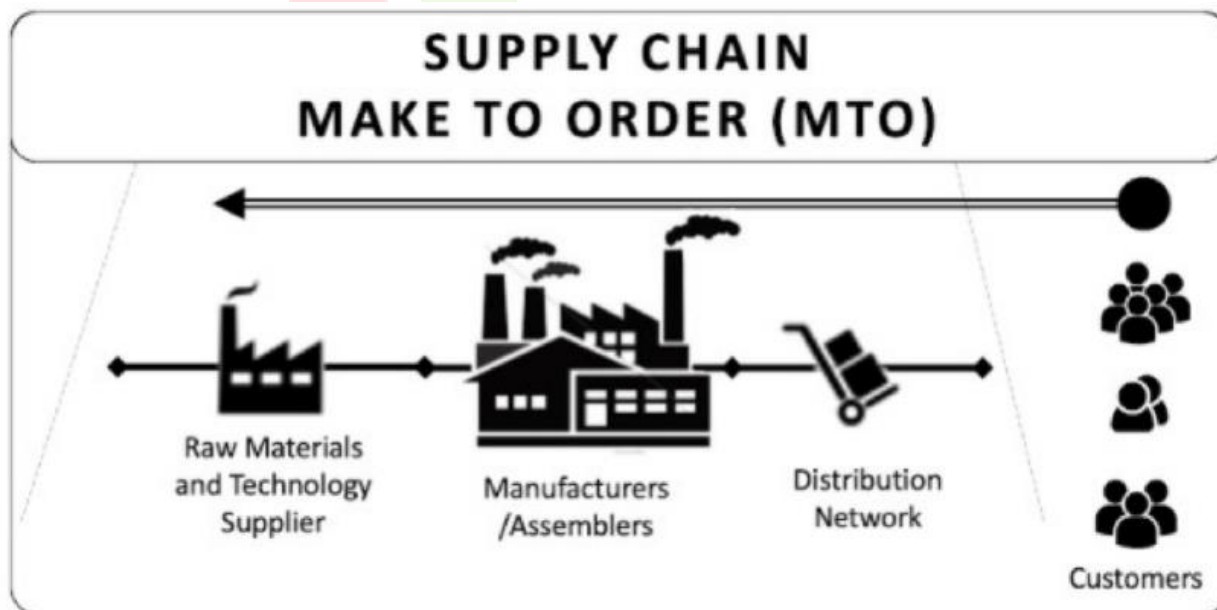


Fig. 3 Operation model. Order-based supply chain (MTO)

Customization is facilitated through MTO modes, which respond to consumer requests and have a limited inventory time. They simultaneously enhance the demand response time due to the acceptance capacity and raw material stock. A smaller batch size and a wide range of variations in raw material consumption and production durations are also part of the process. Inventory levels (WIP and finished items) are therefore kept to a low or even zero in many instances. Responding to an order is theoretically a time-consuming process because companies want to complete all of their tasks before shipping the goods[22].

When a supply chain glitch occurs, a company's operating income, return on sales, and return on assets are all reduced by 100 percent compared to the control firm's results, according to the data (see Figure 4). The two-year period following the announcement of the issue shows no improvement in operational income, sales, total costs, or inventory. In this study, a significant number of supply chain problems are caused by external causes (e.g., related to suppliers or customers) [23].

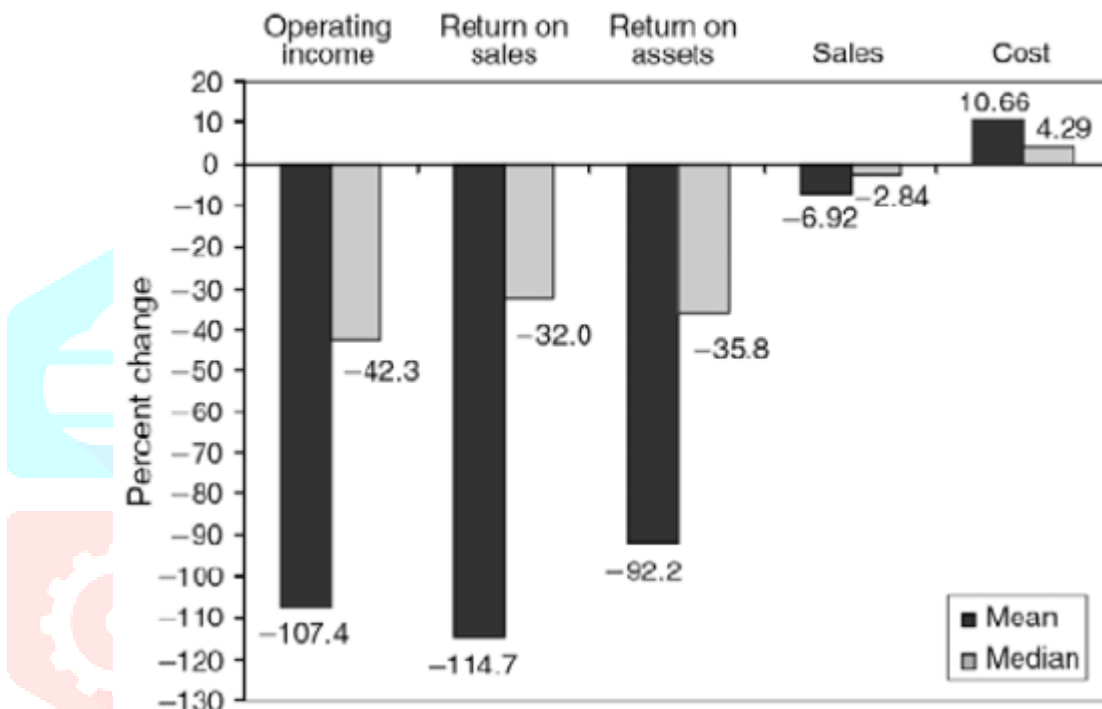


Fig.4 Change in control-adjusted operating performance of firms during the year before the announcement of a supply chain glitch

Network structure and uncertain parameters

Raw resources are transformed into finished goods and then delivered to clients by a supply chain network (SC). The network consists of a variety of facilities, each of which serves a specific purpose. If a facility or customer is served by only one facility from its upstream layer, some studies assume this is the case for material and product flows in a SC network. Furthermore, intra-layer fluxes, which refer to the movement of materials and products inside a single SC layer, have been the subject of some research.[24] Direct flow from upper tiers to customers has also been considered in the literature. In Fig. 5, a typical SC network is depicted with several forms of these material flows.

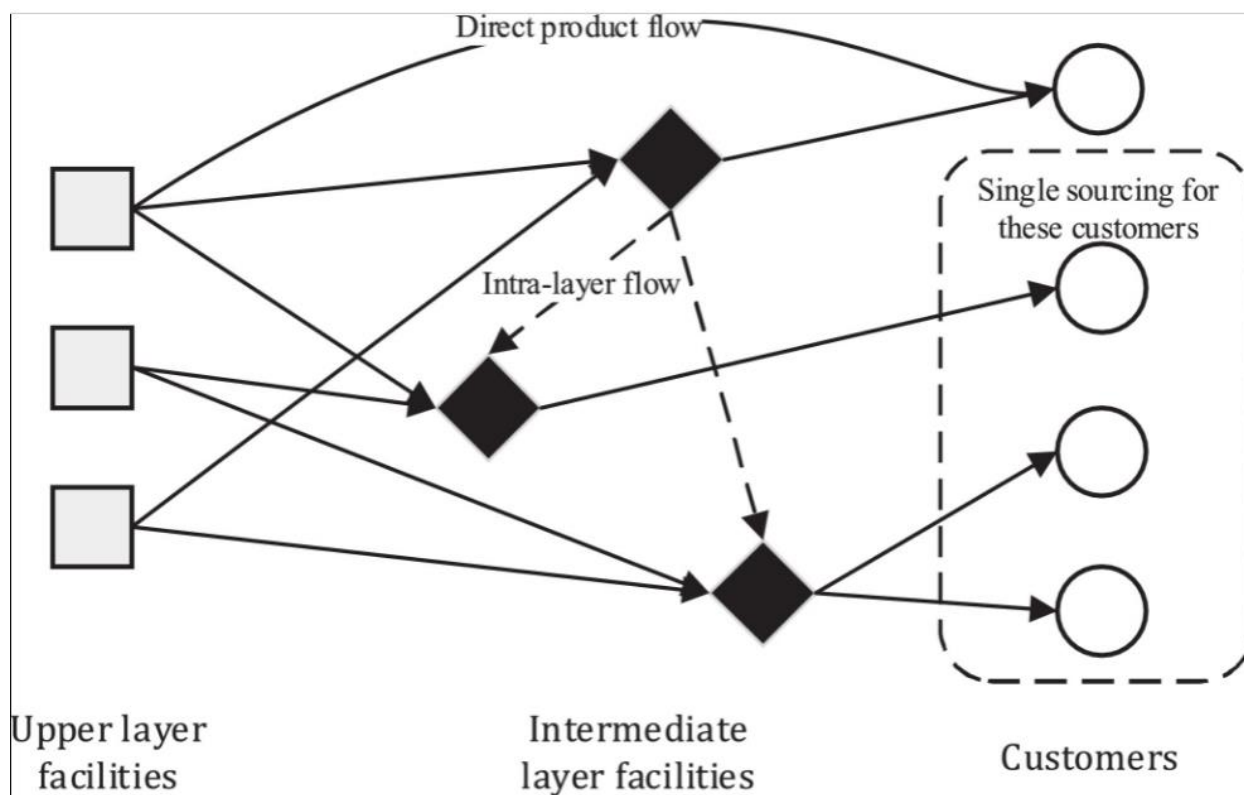


Fig.5 A SC network structure with different types of product flows.

IoT research in the field of SCM and logistics.

We tracked the development of IoT research in supply chain management and logistics (SCM and logistics). A graph depicting the annual distribution of journal papers shows a fluctuating upward trend since 2000. SCM and logistics are seeing a renaissance in the use of IoT applications, as seen by this. As with cloud computing, a resurgence in interest in IoT research can be attributed to the rapid growth of current high-speed networks, which permits quick access to remote data.

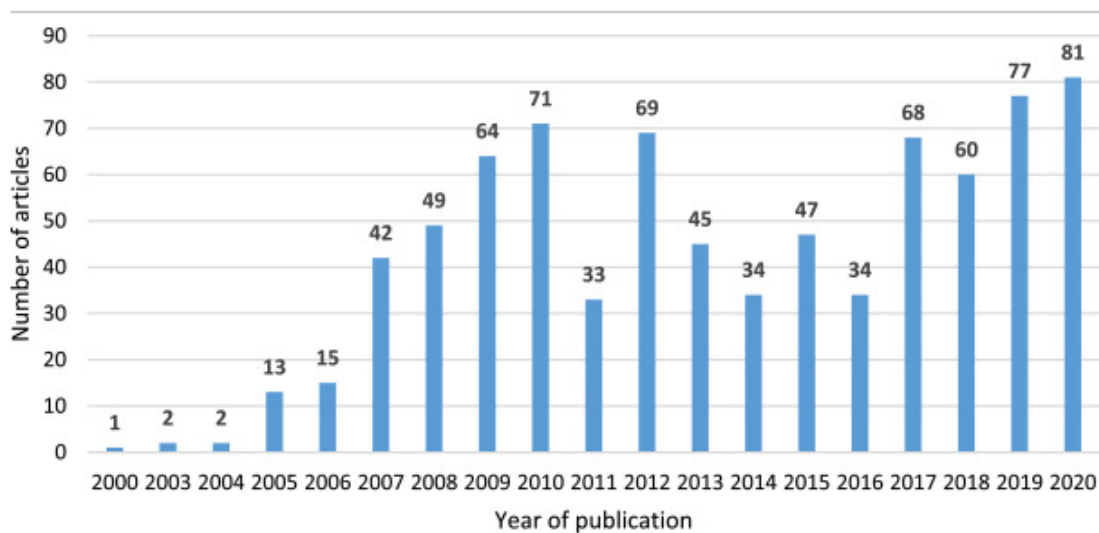


Fig.6 Year-wise distribution of IoT research in the field of SCM and logistics.

Conclusion

Supply chain networks are driven by both external market demand and internal competition-cooperation. Understanding and managing the supply chain system can be accomplished through the use of a building evolution model. We offer a novel evolution model under external market demand and internal competition-cooperation in order to solve the shortcomings of earlier models, which cannot represent the law of supply chain development. An integrated view of systemic risks and their influence on SCS performance and behaviour necessitates taking into account the many structural and behavioural challenges inherent in SCSs.

Using a discount factor to encourage suppliers to offer products and services in line with demand can be extremely beneficial because it promotes relationships between buyers and suppliers in line with the social exchange hypothesis. Suppliers will likely be able to develop more products and services as a result of this, as they will have more financial resources. Marketing and advertising goals should be based on market zone studies and market share values in order to quickly transmit information between buyers and suppliers, resulting in faster reach of products and services. Advertising frequency, rivalry in the marketplace, clutter, market share, and product life cycle stage are all factors to be taken into account. Overall, advertising expenses can be controlled, and the company must set up its advertising budget in accordance with market conditions if it wants to succeed.

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