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Application of modern supply chain in 5G scenario

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Abstract. The continuous innovation and development of information technology and information infrastructure has driven the evolution of the supply form, and with the emergence of 5G, a mobile integrated communication system that includes communication access, interconnection, and connectivity of things, it has now evolved to a modern supply chain of the social organization collaborative type. This paper briefly describes the process of supply chain development, examines the role of communication technology in driving supply chain development, discusses the relationship between modern supply chain and social development and the support of 5G for modern supply chain, and illustrates the application of 5G in modern supply chain scenarios by reducing information time lag in market-side scenarios as an example.

1 Introduction

In the 1980s, companies reached the limit of their ability to reduce production costs and began to reduce costs by exploring a new management model, which led to the emergence of supply chain management [1]. In the production process, the long-term dominant core enterprises from the design, supply, manufacturing and then sales of its supporting upstream and downstream enterprises to integrate, constituting a logistics and information network from the supply side to the retail end [2], this core manufacturing enterprises as the leading supply method for the chain master supply chain [3]. The chain master enterprise makes logistics, capital flow, and information flow circulate in each node of the supply chain through ERP and other information systems [4], and directly or indirectly coordinates and integrates the resource allocation of most enterprises in the supply chain to reduce enterprise costs.

With the rapid development of the Internet in the 1990s, the ability to exchange and share information between enterprises has been improving [5], and especially with the development of mobile Internet in recent years, platform supply chains represented by B2B, B2C, O2O and other models have come into being. Platform supply chains are oriented to users and markets, with transactions as the core, providing a trading platform for legal and natural persons, and users can obtain products through the network, which greatly compresses time and space and solves the universal market synergy of products and livelihood needs [6].

International agriculture, distribution and production have changed radically in the last thirty years. The core part lies in the rapid development of information technology and a high degree of division of labor. Competition among enterprises has evolved into competition among supply chains, and has caused most enterprises to shift from the organizational role of individual enterprise production and sales activities to the role of organizing and integrating supply chains. Many countries have also made supply chain strategy the focus of their industrial development strategy, i.e., to build the smile curve of their advantageous industries globally, and to establish the whole industrial chain and value chain from resources, capital, manufacturing, sales, and service markets [7]. Under this historical trend, the 19th Party Congress put forward the important concept of modern supply chain and gave a profound historical judgment that modern supply chain is a driving force for social and economic development [8,9], which upgraded the development of supply chain to a national strategy. The competition of modern supply chain has evolved from the market competition of supply chain to the all-round competition of the country, and from the system competition of traditional supply chain to the all-round ecological competition

2 Basic concepts and fundamental theories of modern supply chain

2.1. A modern full-role model of supply chain in the context of social cycles

The processes and resources of the cooperative enterprises in the chain, the main set of functions or around the physical space connection, due to the different functions and nature of the system, resulting in information systems around the different nature and functions, divided into a closed information system, the information between the systems can not be connected, and finally formed an information island [10]. The information silo systems all have their specialization, the technology of the physical space and the needs of the information space are better coupled, or the content of the system rarely involves the mapping of multiple logical

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categories of content, and therefore are simple systems [11]. Since the current society has no mutual knowledge function, the supply and demand sides are in a back-to-back state, the market resource matching is not timely and accurate, and the transaction cost is too high. Once the full information space content like social circulation is involved, the simple system fails. Modern supply chain, consisting of three roles of public environment provider, intermediary and market side, emphasizes more accurate and secure supply of resources to achieve social circulation.

2.2 Tripartite role function explanation

The public environment provider holds a large amount of market data, and once the government as a market rule maker is involved in market activities, it will inevitably break the fairness of the market, so we need to build an information ecology through an intermediary party [12]. Third-party organizations represent the management of industry and industrial functions, and the jurisdiction does not have physical space boundaries, while the business impartiality is strong and professional. The public environment provider makes laws and regulations for market operation, while providing physical infrastructure such as roads and information infrastructure such as networks for the normal operation of the market party; the market can accurately acquire user needs through data provided by intermediate parties under the rules set by the public environment provider. Although the scope of the physical space operated by the market party is limited, it can operate in the digital space for the whole physical space under the stable public environment provided by the public environment provider, and the credibility of the intermediary party, which is a non-profit organization, can be used to endorse and realize the transmission of credit.

Modern supply chain evolves from the system of traditional supply chain to the ecology, and the system is closed while the ecology is open. The modern supply chain is oriented to the social cycle and globalized market in the digital era, and mainly solves the synergy problem of social life. Its connotation is extended from the natural physical logic category of production synergy, through the social logic category of market synergy, to the psycho-emotional logic category of social synergy. From production synergy to social synergy, human-human synergy, and finally to achieve synergy and balance between human and nature to realize sustainable development [13].

3 Technology architecture of modern supply chain

3.1. Physical Information Binary Space Survival

Communication technology has accelerated the mapping of people's daily life from physical space to digital space, and human society has moved from the industrial age to the digital age, facing the dual space survival of physical space and information space. The complete cognition of the dual space survival in the digital era and the unified digital information space is the key to study the modern supply chain [14].

With stronger and stronger technical means such as communication and storage, a unified digital information space that can link all information is gradually formed. The unified digital information space is an electronic and digital information ecology based on communication, Internet, Internet of Things and other information infrastructures, with distributed storage and unified electronic coding as information carriers and cell phones, computers and other mobile terminals as access nodes [15,16]. 2015 saw the first time in human history that global production exceeded supply, and human beings gradually entered the distribution-dominated industrial era from the production-dominated industrial era. In 2015, for the first time in human history, global production exceeded supply, and humanity gradually entered the distribution-driven digital era from the production-driven industrial era. The typical value standard of the industrial era is "production is value", and enterprises do not need to pay much attention to the demand-side market; however, the digital era is different, and its value standard has changed to "demand is value" [17,18], and products are no longer sold as soon as they are produced. The reason is that the logic of survival in the digital era is different from that of the demand-side market. The reason is that the logic of survival in the digital era is very different from that in the industrial era. In the industrial era, human beings lived in a physical space of islands, and the sources and uses of information were mostly confined to a single island. With the development of communication network, Internet, Internet of Things and other technologies, human society gradually moves from the industrial era to the digital era, information silos are gradually opened up, and the physical space is no longer symmetrical with the external information space.

3.2. Human-human collaboration, human-net collaboration, human-machine collaboration

The eMBB,uRLLC,.mMTC are the main application scenarios of 5G technology, among which mMTC is a scenario of deep integration of 5G and IoT, arising from the considerable connectivity capability of 5G, whose powerful compatibility makes it possible to realize the whole process from the production to the consumption of products to realize the signal coverage of the whole scenario of - with people, people-net, people-thing, all terminals can be intelligent and the emergence of 5G technology accelerates the mobility of information, and the speed of dissemination of exogenous information compresses the physical space, making the physical information space mirrored by space becomes a point under physical space, people and things can be connected around the world through 5G networks, and physical space and information space tend to converge [19].

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3.3. 5G support for modern supply chains

From the technical level, the core technologies of modern supply chain consist of AI, Bigdata, Blockchain, IOT, and Cloud. Using Big Bigdata and Cloud to store optimized data [20], the modern supply chain is improved by Blockchain, AI, IOT and other core technologies, and data transmission and node communication are carried out through 5G, which in turn empowers various links in the modern supply chain such as production and logistics, creating new models, scenarios and business models such as smart city, smart production and smart logistics, and realizing modern The above applications require a large number of edge computing nodes. The above-mentioned applications require a large number of edge computing nodes, and the characteristics of 5G network with wide connectivity and on-demand networking will provide a stable platform for data interaction and promote computing efficiency. It is an indispensable part of the development of modern supply chain, providing a strong technical guarantee.

4 5G in modern supply chain scenarios

The information time lag effect, also known as the supply chain long-whip effect, refers to the fluctuation of product orders in the supply chain that is much larger than the real market demand and is amplified with the supply chain step by step. The information time lag effect can mislead production planning, resulting in effects such as inventory buildup, reduced revenue, and ineffective transportation [21]. This chapter elaborates on the application of 5G in modern supply chain scenarios by using 5G in market-side scenarios to reduce the information time lag effect as an example.

4.1. Information time lag effect model construction

The economic development of the country consists of several industrial chains, and each industrial chain is constituted by a number of real economic agents in different links of the supply chain, and these trading agents form a supply chain through the supply and demand trading relationship between upstream and downstream. Therefore, a supply chain consisting of Consumer side, retail side, wholesale side, manufacturing side, supply side can be constructed to abstractly describe the transaction relationship in any supply chain.

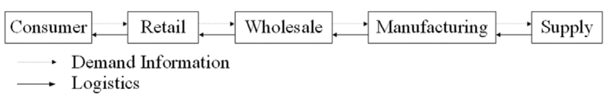

Fig. 1. Five-level supply chain model.

In Figure 1 above, the supply side has raw materials, parts and other production materials, and the manufacturing side has advanced technology and tools and equipment to produce products, and the goods are circulated to the consumer market through the wholesale side, and the products eventually need to be delivered to the consumer side by the retail side.

4.2. Modeling the time lag effect of supply chain information in the current network environment

To analyze the impact of 5G networks on the information time lag effect, a quantitative model based on the AR(1) demand mean square error optimized to predict the information time lag effect of the five-level supply chain information sharing is established, and the parameters involved in the model are detailed in the following table[22].

Table 1. Description of model symbols.

Model symbols	Description
t	Time frame for the transaction to take place
L_n	Replenishment stock preparation period
D_t	Retailers face the market consumer demand
Q_t	Volume of orders placed by retailers to suppliers
T_n	Upstream buyers' stocking period
λ	Correlation of market consumption demand between two adjacent periods
ε_t	Market consumer demand fluctuation error
$\hat{D}_t^L$	Retailers use the moving average method to estimate the market demand for period L starting in period t
Y_t	The maximum inventory level calculated by the retailer using the order point method

Based on the rationality of the supply chain system, the following assumptions are made for this model to simplify the calculations.

1. In this model consists of consumers, retailers, wholesalers, manufacturers, and suppliers, and each party is an independent decision maker, and the purpose of the decision is to ensure that their own interests are maximized [23], and the upstream and downstream are the only buyers and sellers of each other, and they trade and only trade the same product between them.

2. The buyer and seller trade in discrete time, $t=-\infty,\cdots,-1,0,1,\cdots,\infty$.

3. At the end of period t, the downstream buyer will consider replenishment from the upstream seller based on past sales.

4. In the current network environment, due to a series of reasons such as data collection, data aggregation, processing and calculation by sensors, the final information cannot be delivered in real time when it is sent to upstream members of the supply chain, and a delivery delay will occur. Therefore, the replenishment stocking period includes the downstream buyers' sales information collection and processing period H_n, and the upstream sellers' stocking period T_n. For the convenience

of calculation, let the upstream sellers' replenishment stocking period be L_n, L_n=H_n+T_n.

5. The demand is predicted by mean square error optimization forecasting for the period t+L_n and the order $Q_t^{(n)}$ is issued to the seller at the beginning of t+L_n and the buyer receives the goods at t+L_n+1.

6. To quantify the model, let the number of supply chain levels be k, from consumer to supply s is divided into k=0,1,2,3,4

The retail side faces the market consumer demand Dt as an AR(1) autocorrelated time series of.

$$D_t=\mu+\lambda D_{t-1}+\varepsilon_t(t=0,\pm1,\pm2,\cdots) \tag{1}$$

From the model of information time lag effect in secondary supply chain proposed by HL Lee [24,25], the information time lag effect can be reduced to solving $\frac{\mathrm{var}(Q_t)}{\mathrm{var}(D_t)}$.

Therefore, for the five-level supply chain information time lag effect, the demand estimation $\widehat{D}_{t+i}$ at the retail end for period t+i is

$$\widehat{D}_{t+i}=\mathrm{E}\left(D_{t+i} \mid D_t\right) \tag{2}$$

Recursion on (1) yields the following relationship.

$$D_{t+i}=\frac{1-\lambda^i}{1-\lambda}\mu+\lambda^i d_t+\lambda^{i-1}\varepsilon_{t+1}+\lambda^{t-2}\varepsilon_{t+2}+\cdots+\varepsilon_{t+i} \tag{3}$$

Since ε_t is a random variable with independent identical distribution, for any i=1,2,3... there are.

$$\mathrm{E}\left(\varepsilon_{t+i} \mid D_t\right)=0 \tag{4}$$

$$\widehat{D}_{t+i}=\mathrm{E}(D_{t+i}|D_t)=\frac{1-\lambda^i}{1-\lambda}\mu+\lambda^i D_t \tag{5}$$

And the total retailer's estimate of demand within the stocking period L is

$$\widehat{D}_t^L=\sum_{i=1}^{L}\left(\frac{1-\lambda^i}{1-\lambda^\mu}\mu+\lambda^i D_t\right)=\frac{\mu}{1-\lambda}\left[L-\frac{\lambda\left(1-\lambda^L\right)}{1-\lambda}\right]+\frac{\lambda\left(1-\lambda^L\right)}{1-\lambda}D_t \tag{6}$$

The order quantity on the supply side in the retail direction is

$$Q_t=\widehat{D}_t^L-\widehat{D}_{t-1}^L+D_t=\left[1+\left(\frac{1-\lambda^L}{1-\lambda}\right)\lambda\right]D_t-\left(\frac{1-\lambda^L}{1-\lambda}\right)\lambda D_{t-1} \tag{7}$$

Under the premise of shared retailer demand information, either level of upstream members, when optimizing forecasting techniques and point-of-order inventory by means of mean squared deviation, the following conditions are met for ordering credits..

$$\begin{cases} D_t^{(k)}=Q_t^{(k-1)}+Y_t^{(k)}-Y_{t-1}^{(k)} \\ Y_t^{(k)}=\widehat{D}_t^L \\ \widehat{D}_t^L=\frac{\mu}{1-\lambda}\left[L-\frac{\lambda\left(1-\lambda^L\right)}{1-\lambda}\right]+\frac{\lambda\left(1-\lambda^L\right)}{1-\lambda}D_t \end{cases} \tag{8}$$

According to the above formula. It can be derived that when k = 2, that is, the wholesale end of the order quantity output is.

$$Q_t^{(2)}=Q_t^{(1)}+\widehat{D}_t^L-\widehat{D}_{t-1}^L=\left[1+\frac{2\lambda\left(1-\lambda^L\right)}{1-\lambda}\right]d_t-\frac{2\lambda\left(1-\lambda^L\right)}{1-\lambda}D_{t-1} \tag{9}$$

Similarly, it can be derived that when k = 3, 4, i.e., the manufacturer, the supplier whose order quantity output is respectively

$$Q_t^{(3)}=\left[1+\frac{3\lambda\left(1-\lambda^L\right)}{1-\lambda}\right]D_t-\frac{3\lambda\left(1-\lambda^L\right)}{1-\lambda}D_{t-1} \tag{10}$$

$$Q_t^{(4)}=\left[1+\frac{4\lambda\left(1-\lambda^L\right)}{1-\lambda}\right]D_t-\frac{4\lambda\left(1-\lambda^L\right)}{1-\lambda}D_{t-1} \tag{11}$$

For any k-level supply chain members

$$Q_t^{(k)}=\left[1+\frac{k_\lambda\left(1-\lambda^L\right)}{1-\lambda}\right]d_t-\frac{k_\lambda\left(1-\lambda^L\right)}{1-\lambda}D_{t-1} \tag{12}$$

Therefore, for AR(1) demand, the information time lag effect in the multi-level supply chain when members at all levels of the supply chain share retailer demand information and use mean squared optimal forecasting techniques and point-of-order inventory strategies to determine order quantities is

$$\frac{\mathrm{var}\left(Q_t^{(k)}\right)}{\mathrm{var}(D_t)}=1+2k\lambda\left(1-\lambda^L\right)\left[1+\frac{k\lambda\left(1-\lambda^L\right)}{1-\lambda}\right] \tag{13}$$

Take value L=6, T_n=5, H_n=1,λ=0.9, σ =1, Modeled by Matlab, the simulation test results are shown below

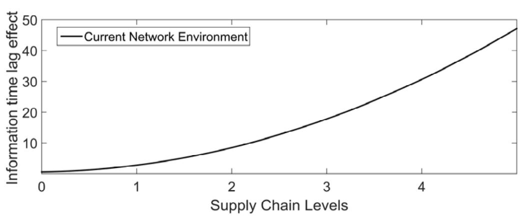

Fig. 2. Time delay effect of supply chain Information in current Network Environment.

4.3. Modeling the time lag effect of supply chain information in 5G network environment

The high bandwidth of 5G networks enables real-time synchronization of information, timely and effective transmission among supply chain members, and acts as a control tower. This integrated information transfer model enables the highest level of information sharing among supply chain system members, and therefore enables control and decision-making from the supply chain as a whole.

Compared with the past network environment, in the 5G network environment, the members in the supply chain can synchronize the information to the information integration center and pass it to each other in real time because the data collection and aggregation by sensors can be synchronized in real time and the data can be calculated quickly with the addition of artificial intelligence. Therefore, according to the model built above, in 5g network conditions, $L_n=T_n$ indicates the preparation period, so that.

$$\frac{\mathrm{var}\left(Q_t^{(k)}\right)}{\mathrm{var}(D_t)}=1+2k\lambda\left(1\text{-}\lambda^T\right)\left[1+\frac{k\lambda\left(1\text{-}\lambda^T\right)}{1\text{-}\lambda}\right] \tag{14}$$

Take value L=5.1, T_n=5, H_n=0.1, λ =0.9, σ =1 , Modeled by Matlab, the simulation test results are shown below

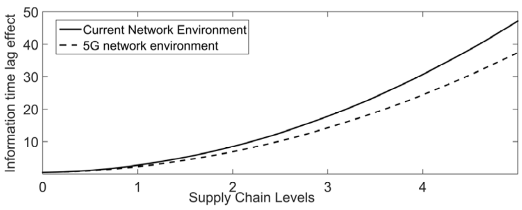

Fig. 3. Comparison of time delay effect of supply chain Information in 5G Network Environment.

In order to observe the impact of 5G network on reducing the information time lag effect more intuitively, the time lag effect between the same supply chain level in the 5G environment and the current network environment is taken as the difference, and the step-by-step expansion of the impact of 5G on the information time lag effect is obtained, and the model is established by Matlab, and the simulation test results are shown in the following figure.

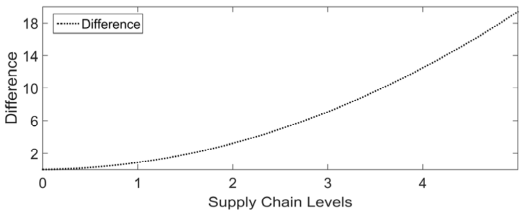

Fig. 4. Information time lag effect difference.

From Figure 4, it can be seen that with the increasing number of supply chain levels, the more obvious the role of 5G in reducing the information time lag effect. 5G network is now low latency, but there is still time delay, and if the ideal network environment with zero latency and ultra-high speed computing is developed in the future, what is the impact on the information time lag effect. Therefore, let the information collection and processing period H_n be 0. The model is established by Matlab, and the simulation test results are shown below

The simulation results can be concluded that the information time lag can be reduced in the ideal network environment with zero latency and ultra-high speed, but the effect is limited and the difference in impact with the 5G network environment is not significant.

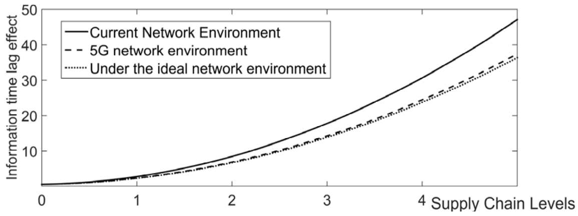

Fig. 5. Comparison of time delay effect of supply chain Information in ideal Network Environment.

The high bandwidth, low latency and wide connectivity of 5G network can effectively link the dispersed supply chain members into a whole, thus realizing the most comprehensive collaborative management. This can greatly reduce the time lag effect of information in the supply chain.

5 Conclusion

The modern supply chain has opened up information silos through the collaboration of all factors and resources, eliminated information asymmetry, and enabled resources to be explored and utilized continuously. By combing the evolution of supply chain, this paper concludes that the development of supply chain is closely related to the development of information infrastructure, and deduces the historical inevitability of the emergence of modern supply chain and that 5G as a network layer is an essential module in the development of modern supply chain system. Through Matlab simulation, it is concluded that the real-time synchronization of information of supply chain members at all levels in the 5G environment can reduce the information time lag effect in the system.

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