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Calculation Method's Research of Interruption Probability of Online Economic Transaction Based on Bayes Information Fusion

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Abstract: *The problem of economic transaction interruption under the crisis of online economic transaction interruption is analyzed. It is pointed out that there is an unreliable supplier in the online economic transaction manufacturer. When the supplier fails, there is a problem in the selection of two standby reliable suppliers, and the customer service factor is taken into account. By using a Bayes information fusion method and lingo software, we establish a mathematical model to calculate the procurement cost, supplier transaction cost and customer shortage cost and solve the optimal selection scheme. Finally, a sensitivity analysis is carried out on the relevant scenario parameters to obtain the numerical test and sensitivity analysis results. The expected total income of online economic transactions is the largest in the CPD model by comparing the four models of online economic transactions. Compared with three non-centralized online economic transaction models, the expected total income of online economic transactions is the largest in the NGPD model.*

Keywords: *Bayes, Information fusion, Online trading, Economic risk, Transaction interruption*

1. Introduction

The occurrence of supply interruption causes direct loss of enterprises in online economic transactions and complaints from consumers and brings an indirect impact on enterprises [1,2]. In order to analyze the impact of interruption risk on online economic transactions specifically, a dual channel online economic transaction is considered, including manufacturers, retailers, and consumers. Manufacturers sell their products to retailers through offline retail channels or to end consumers through online direct sales channels. When the manufacturer is broken, all orders from offline retail channel retailers and online customers are not available [3]. Therefore, manufacturers need to bear the penalty of interruption from downstream retailers and consumers at the same time. Retailers, however, only need to bear the punishment from the consumer. We analyze four online economic transaction models based on different market capacity structures and provide the optimal decision of each member by using game theory. The sales price under different models is also proposed. It is found that no matter what market capacity model, the sales price is higher than that without considering the interruption risk [4]. Under different market capacity models, the sales price of online direct marketing channels is the same, while the sales price of offline retail channels is affected by different market shares. In addition, an additional numerical analysis is made for the corresponding expected return [5]. Finally, the sensitivity analysis of other parameters is made, and their influence on price decisions and expected return is analyzed.

2. Calculation of Interruption Probability of Online Economic Tansaction

2.1. Online economic transaction risk model

In the same market environment, three retailers with different risk attitudes are constructed, representing three types, which are risk biased, risk neutral and risk averse [6]. Twenty suppliers are randomly selected for retailers. Considering the limitation of retailer's search scope, it is assumed that each retailer can choose up to five suppliers per cycle, regardless of supplier's risk attitude, The upstream and downstream enterprises sign contracts on a series of terms such as price and lead time at the beginning of ordering. However, due to various factors, such as natural disasters, equipment failure, raw materials and other reasons, the upstream supply is interrupted, which can not meet the downstream orders. Therefore, through the computational experimental method to explore the impact of supply disruption risk under different retailers' risk decision-making attitude and its coping strategies [7]. Online economic transaction is a network structure composed of upstream and downstream enterprises through certain relationships, which embeds interruption risk events into upstream and downstream relationships[8]. The evolution of decision-making process of upstream and downstream enterprises over time can be described as Fig. 1 .

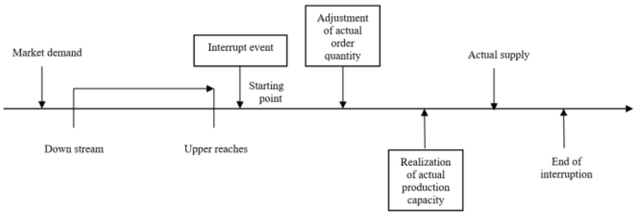

Figure 1: Description of supply disruption risk process

Through the analysis of the risk sources of online economic transaction interruption, there are many reasons for supply interruption. The external environment factors of the existing economic transactions on the line, such as political, economic, and cultural factors, also include the factors of online economic transactions, such as single suppliers, excessive pursuit of lean online economic transactions, and others [9]. According to the characteristics of online economic transactions, the risk of offline economic transaction interruption is divided into two types: supply node interruption and online economic transaction interruption in uncertain situations [10]. In a three-level online economic transaction composed of suppliers, manufacturers, and retailers, the risk of interruption of offline economic transactions mainly occurs upstream of online economic transactions in uncertain supply situations [11].

In general, risk management of online economic transactions is divided into five stages, namely, risk identification, risk assessment, risk prevention, risk resolution, and risk monitoring, as shown in Fig. 2 [12]. Among them, risk identification is to judge and classify the risks faced or potential by online economic exchanges. Risk assessment is to calculate the probability of identified risks and estimate the impact to be caused [13]. Risk prevention is to prevent the occurrence of risks. Resolving the risk is to take a series of strategies to reduce the loss caused by the risk and resume online economic transactions as soon as possible when the risk occurs. Monitoring risk is to timely monitor the current risk level as shown in Fig. 2.

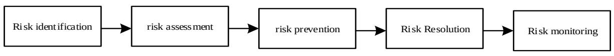

Figure 2: Steps for risk identification of economic transaction interruption.

At time T, downstream enterprises choose their decision-making methods according to external demands and establish contracts with upstream enterprises to determine the order quantity [14]. At time T1, upstream enterprises choose their decision-making methods and determine the supply quantity according to the order quantity, product lead time, and established contract. Between T1 and T2, when the emergency occurs with probability a and the duration is t, the downstream enterprises need to adjust the order quantity in time for the interruption. Then, the upstream enterprises produce according to the actual capacity. At T2, the actual supply is completed [15]. The model assumes that the leading enterprise knows that the following enterprise will respond to its output. Thus, when it determines the output, the response of the following enterprise is taken into account. This model is called the "leading enterprise model". It is illustrated in Ref. [16]. There are two manufacturers in a market, which produce the same products, among which, manufacturer A is the leader and manufacturer B is the follower. Their cost function is as follows.

$$\begin{cases} TC_A = 1.2Q_A^2 + 2 \\ TC_B = 1.5Q_B^2 + 8 \end{cases} \tag{1}$$

The low-cost manufacturers are the leaders and the high-cost manufacturers are the followers. The anti-demand function of the market is $P = 100 - Q$, of which $Q = Q_A + Q_B$ .Considering the behavior of followers first, the profit of manufacturer B is calculated as

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$$\begin{aligned}\Pi_B &= P\times Q_B - TC_B \\ &= (100 - Q_A - Q_B)\times Q_B - \left(1.5Q_B^2 + 8\right) \\ &= 100Q_B - Q_AQ_B - 2.5Q_B^2 - 8\end{aligned} \tag{2}$$

Then, the first order condition of profit maximization is as follows.

$$\frac{\partial \Pi_B}{\partial Q_B} = 100 - Q_A - 5Q_B = 0 \tag{3}$$

The response function of manufacturer B is,

$$Q_B = 20 - 0.2Q_A \tag{4}$$

Considering the behavior of the leader, the profit of manufacturer A is

$$\begin{aligned}\Pi_A &= P\times Q_A - TC_A \\ &= (100 - Q_A - Q_B)\times Q_A - \left(1.2Q_A^2 + 2\right) \\ &= \left[100 - Q_A - (20 - 0.2Q_A)\right]\times Q_A - \left(1.2Q_A^2 + 2\right) \\ &= 80Q_A - 2Q_A^2 - 2\end{aligned} \tag{5}$$

The first-order condition for maximizing profit of leading manufacturer A is

$$\frac{\partial \Pi_A}{\partial Q_A} = 80 - 4Q_A = 0 \tag{6}$$

The optimal solution is as follows.

$$\begin{cases} Q_A = 20 \\ Q_B = 16 \\ P = 64 \end{cases} \tag{7}$$

Therefore, the market price of the final product is 64, the profit of leader firm a is 798, and that of follower firm B is 632. It is divided into two models: the model with the manufacturer and the model with the retailer as Stackelberg leader. When the manufacturer has a Stackelberg leader model, the manufacturer considers the reaction of the downstream retailers to the decision. The retailer arranges the production planning decision according to the manufacturer's decision. Conversely, it is similar when the retailer follows a Stackelberg leader model.

2.2. Calculation of impact degree of economic transaction interruption risk

We consider the dual channel online economic transaction problem consisting of a manufacturer and a retailer under disruption risk. Manufacturers also carry out offline retail channels and online direct sales channels to sell products [17]. If the manufacturer suffers from the risk of supply disruption, then all the product orders by the retailer and the manufacturer's online direct sales channels are interrupted. In order to facilitate the establishment of the model, it is assumed that in the extreme case, the supply is zero [18]. To compare and study the price decisions among members under different market structures, four structural models are established according to their different market power relationships. It is found that an interruption can increase the sales price of products in any market structure compared with online economic transactions [19]. In addition, the sales price of the online direct channel is the same under different model structures, but the sales price of the offline retail channel is affected by the market share of each member in a different structure. When the transaction flexibility of the online economy increases, the cost of lean production also increases but the loss caused by interruption risk reduces. Thus, we use elastic cost to express the cost increase brought by the increase of elasticity, and elastic income to express the loss reduction brought by the increase of elasticity [20,21]. The marginal elastic cost represents the increase of cost brought by the increase of one unit elastic level, and the marginal elastic income represents the decrease of loss brought by the increase of one unit elastic level. The equilibrium point should be located at the intersection of marginal elastic cost and elastic benefit.

Additional numerical analysis is also made to compare the results under different model structures, such as income and profit. The most expected return function is given, and the expected return under penalty cost is smaller than that without penalty cost. In addition, the influence of several parameters on the optimal price decision and the optimal expected return function is analyzed. Considering a two-tier and dual-channel online economic transaction consisting of a manufacturer and a retailer, manufacturers can sell products to consumers through offline retail channels, namely, through retailers, retailers to customers, or directly to customers through online direct sales channels. Therefore, manufacturers should not only determine the wholesale price r_p of products connected with retailers through offline retail channels but also determine the product sales price P2 of online direct channels to customers. For the market demand, retailers only need to decide the product sales price P1. The demand function of the offline retail channel is

$$d_1\left(p_1, p_2\right) = \theta\alpha - \beta_p p_1 + r_p\left(p_2 - p_1\right) \tag{8}$$

The demand function of online direct channel is as follows.

$$d_2\left(p_1, p_2\right) = (1-\theta)\alpha - \beta_p p_2 + r_p\left(p_1 - p_2\right) \tag{9}$$

In the above equation, subscripts 1 and 2 represent the traditional retail channel and online direct sales channel respectively, parameter α represents the potential market scale of products, parameter θ represents the market scale proportion of the traditional retail channel, and $1-\theta$ represents the market scale proportion of direct sales channel.

If AHP is adopted, the supplier is evaluated and selected from the aspects of product quality, price, delivery, and other factors of the supplier. If AHP is used, the selection problem can be solved more effectively through the visual basic programming language. The supplier is screened by the TOPSIS method, and the SPEA2 algorithm is applied to the supplier selection problem. Schmitt and Snyder believed that there are reliable suppliers and reliable suppliers with higher costs and easy to be disturbed and unreliable in the enterprise. Therefore, the development model is made to solve the optimal order and inventory quantity. In the study of online economic transaction interruption, the service level is rarely considered. Given the service level, it is suggested that the security inventory strategy of improving the service level must be made in the case of an increase in cost. In the process of studying supplier selection, two optimization models based on constraint conditions are established. Under the overall budget constraints, the service level is maximized and the total cost is minimized when the target service level is achieved. Under the risk of interruption of multi-stage online economic transactions, Schmitt studied the issues to protect customer service levels by using inventory, strategic reserve, standby distribution center, and standby plant strategy, as shown in Fig. 3.

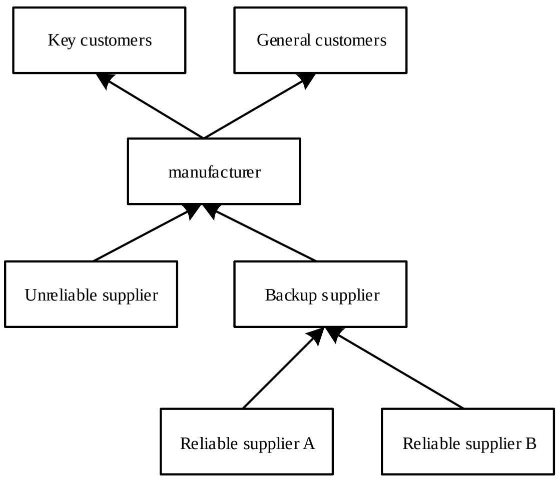

Figure 3: Online economic transaction management model.

There are three suppliers: unreliable but lower price supplier, reliable but higher price supplier, and reliable but slightly higher price supplier B. Manufacturers take unreliable suppliers as their main suppliers and need to choose a reliable supplier as their backup supplier. The price of supplier A is higher, but the transaction cost is lower due to the closer distance. The price of supplier B is higher, but the transaction cost is higher due to the farther distance. In this study, customer service is considered,

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and the manufacturer's customers are divided into key customers and ordinary customers. Considering the difference in the shortage cost between different customers, the optimal choice of manufacturer under various situational factors is studied. In all processes of online economic transaction management, risk prevention is the key, because once the risk becomes a reality, no matter how big or small, it causes certain losses to an online economic transaction. Therefore, the principle of prevention must be implemented in an online economic transaction, and risk prevention must be prioritized. Because of the abruptness and unpredictability of interruption risk, the key point of online economic transaction risk prevention lies in the prevention of interruption risk. For the prevention of interruption risk, the key is to apply the limited prevention resources to the weak links that are prone to interruption in online economic transactions. Generally speaking, nodes are most likely to have problems and form the "bottleneck" of online economic transactions. The weak links of online economic transactions are identified through the following process, as shown in Fig. 4.

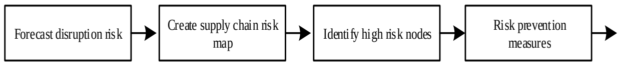

Figure 4: Risk identification of online economic transaction interruption.

The main measure to prevent the interruption risk of online economic transactions is to enhance the flexibility of online economic transactions. Online economic transaction flexibility refers to the ability of the online economic transaction network system to return to the initial state or ideal state after suffering from interruption risk. To improve the flexibility of online economic transactions, flexibility, reliability, and coordination need to be considered. Reliability is mainly reflected in stability and anti-interference. Synergy is mainly reflected in coordination and cooperation.

2.3. Probability calculation of online economic transaction terminal

Usually, the occurrence of production interruption events in online economic transactions is sometimes inevitable and has a great impact on the performance of online economic transactions. Machine failure and shortage of raw materials are examples. The connection diagram of the online economic transaction network is represented by 'the total number of node enterprises in the online economic trading network n. The product flow, capital flow, information, and technology flow among enterprises of each node are the edges of the online economic transaction network, and the total number of edges of the online economic trading network is m. The number of edges of node enterprise I connected to other nodes of the node is the degree of the enterprise of the node, expressed in K_i. The larger the degree of a node enterprise in the online economic transaction network, the more the enterprise has product flow, capital flow, and information technology flow, the higher the importance, and the more likely it is the key node enterprise. The average degree $<k>$ is the average value of the degree K_i of all nodes i in the online economic transaction network.

$$<k>=\frac{1}{N}\sum_{i=1}^{N}K_i \tag{10}$$

Under the scale-free network structure, both the number of nodes and the edge relationship of the online economic transaction network are dynamic. Therefore, once the interruption risk occurs, each node enterprise can spontaneously or passively adjust the existing strong connection and weak connection relationship, change the transmission path of online economic transaction interruption risk, and reduce the enterprise's risk or loss. Specifically, the first is to change the existing connection relationship and establish more weak connections between the same level or adjacent level in the online economic trading network and other online economic trading networks. The second is to transform weak connections into strong connections before or at the time of emergency to weaken or transfer the possible interruption risk. A large number of weak connections and strong connections form a relatively independent internal network structure with node enterprises as the core. Compared with the overall network of online economic transactions, it is more flexible to immediately avoid and transfer the impact of the interruption risk of online economic transactions and reduce the solidification impact of the organizational structure of the online economic transactions network. The core enterprises of online economic transactions have stronger and weaker connections than the general node enterprises, and the degree value is relatively large. The larger and faster the amount of risk information (especially sensitive information) is, the stronger the ability to transfer, disperse, or avoid the interruption risk in time. Vertex degree is the relative index of the enterprise degree of each node, which reflects the relative importance of its online economic trading network.

$$I_i = \frac{K_i}{\sum_{i=1}^{N} K_i - < k >} \tag{11}$$

The higher the vertex degree of a node enterprise, the more likely it is to be a key node. When the degree of each node enterprise is close, the online economic transaction network may be a homogeneous network with uniform distribution. When the degree of each node enterprise is different, each node enterprise tends to connect with the node enterprise to a large degree, and the online economic transaction network may be heterogeneous. The homogeneity and heterogeneity of online economic transaction networks can be measured by the network structure $H(G)$.

$$H(G) = -\sum_{i=1}^{N} I_i \ln I_i \tag{12}$$

The degree distribution function of node enterprises in an online economic transaction network refers to the probability when the degree of a randomly selected node enterprise is exactly k , which is expressed by *p*. For *Ba* network, the total number of existing online economic transaction node enterprises is n . The online economic transaction network continuously introduces new node enterprises, and each of new node enterprise is one. The new node enterprise is connected with m existing node enterprises to meet the requirement of $m < n$. $P(k,t_i,t)$ is defined as the probability when the degree of the node i added at t' is exactly k at t, which has the following recurrence relation.

$$P\left(k,t_i,t+1\right) = \frac{k-1}{2t} P\left(k-1,t_i,t\right) + \left(1-\frac{k}{2t}\right) P\left(k,t_i,t\right) \tag{13}$$

The degree distribution function can be obtained by the master equation method.

$$P(k) = \frac{2m(m+1)}{k(k+1)(k+2)} \propto \frac{2m^2}{k^3 P\left(k,t_i,t+1\right)} \tag{14}$$

Numerical simulation and analysis are mainly from the single statistical parameter simulation and analysis. In the aspect of single statistical parameter simulation and analysis, the utilization and average analysis of online economic transaction network characteristics are more intuitive and have no direct correlation with network heterogeneity and scale-free characteristics. There is no relevant simulation and analysis because vertex degree and network structure entropy are used to judge the heterogeneity of online economic transaction networks. Only network structure entropy is selected for simulation and analysis. In this study, the index of the degree distribution function is selected for simulation and analysis, which is mainly used to judge the scale-free characteristics of an online economic trading network. From the characteristic path length index, it is judged that a scale-free network also has small-world characteristics, so it is unnecessary to simulate and analyze the characteristic path length index. Therefore, in the aspect of single statistical parameter simulation and analysis, numerical simulation and analysis are mainly carried out on the three indexes of network structure, degree distribution function, and agglomeration coefficient.

When production interruption occurs, the manufacturer cannot meet any downstream production order, facing a penalty of breach of contract. Because manufacturers have both offline retail channels for retailers and online direct sales channels for customers, they face two penalties. The punishment faced by the offline retail channel is regarded as internal punishment, and the unit shortage cost is expressed as w . The penalty cost of the online direct sales channel is regarded as an external penalty, and the unit out-of-stock cost is expressed by q_r . Let ε denote the probability of interruption. Manufacturer's profit without interruption.

$$\Pi_{M_1}\left(w, p_2\right) = (w-c) d_1\left(p_1, p_2\right) + \left(p_2 - c\right) d_2\left(p_1, p_2\right) \tag{15}$$

where c is the unit production cost. In the event of an interruption, the manufacturer's profit is defined as

$$\Pi_{M_2}\left(w, p_2\right) = -qd_1\left(p_1, p_2\right) - q_r d_2\left(p_1, p_2\right) \tag{16}$$

Therefore, considering the interruption, the manufacturer's expected profit is as follows.

$$\begin{aligned}\Pi_M\left(w, p_2\right) &= (1-\varepsilon)\Pi_{M_1}\left(w, p_2\right) + \varepsilon\Pi_{M_2}\left(w, p_2\right) \\ &= (1-\varepsilon)\left[(w-c)d_1\left(p_1, p_2\right) + \left(p_2 - c\right)d_2\left(p_1, p_2\right)\right] - \varepsilon qd_1\left(p_1, p_2\right) - \varepsilon q_x d_2\left(p_1, p_2\right)\end{aligned} \tag{17}$$

Next, the profit function of the retailer is given. Retailer's profit when no interruption occurs.

$$\Pi_{R_1}\left(p_1\right) = \left(p_1 - w\right)d_1\left(p_1, p_2\right) \tag{18}$$

When the interruption occurs, the retailer obtains compensation from the manufacturer. In addition, retailers also face external punishment from online economic transactions and receive compensation from manufacturers. Therefore, when the interruption occurs, the retailer's profit is

$$\Pi_{R_2}\left(p_1\right) = \left(q - q_r\right)d_1\left(p_1, p_2\right) \tag{19}$$

Therefore, in the case of disruption, the retailer's expected profit.

$$\begin{aligned}\Pi_R\left(p_1\right) &= (1-\varepsilon)\Pi_{R_1}\left(p_1\right) + \varepsilon\Pi_{R_1}\left(p_1\right) \\ &= (1-\varepsilon)\left(p_1 - w\right)d_1\left(p_1, p_2\right) + \varepsilon\left(q - q_r\right)d_1\left(p_1, p_2\right)\end{aligned} \tag{20}$$

To analyze the impact of interruption on the decision-making of members in online economic transactions, we consider how the decision-making of manufacturers and retailers changes under the market structure composed of different market forces. Therefore, we further assume that the information obtained by all members is fully effective.

3. Analysis of Experimental Results

We analyze the optimal price decision and optimal profit decision of each member of dual channel online economic transaction under interruption risk. To carry out the numerical calculation simply,

$$\alpha = 1000, c = 20, \beta_p = 8, r_p = 6, \Lambda_p = 14, \theta = 0.6, \varepsilon = 0.3, q = 4, q_r = 1.5 \tag{21}$$

Based on the above algorithm, we draw the following conclusions in Table 1.

Table 1: Equilibrium solution of each decision variable

	q_r=0				q_r≠0			
Model	P1	P2	W	P1-W	P1	P2	W	P1-W
MSPD	51.61	38.75	45.46	6.15	51.84	39.07	45.14	6.70
RSPD	51.61	38.75	37.61	14.00	51.84	39.07	37.38	14.46
NGPD	48.99	38.75	40.23	8.76	49.25	39.07	39.97	9.28
CPD	43.75	38.75			44.07	39.07		

The optimal selling price of manufacturers under direct marketing channels is the same among the four online economic transaction models. The optimal sales price of retailers in traditional channels is the maximum value in RSPD (MSPD) model, followed by NGPD, and the lowest in CPD. The optimal wholesale price of manufacturers in traditional channels is the largest in the MSPD model, followed by NGPD, and the last is the lowest in RSPD.

The retailer's marginal income is the largest in the RSPD model, followed by the value of NGPD, and the lowest in NGPD.

The optimal sales price of the two channels with an externality penalty is higher than that of the non-external punishment. However, the optimal wholesale price is higher when there is externality punishment than that without externality punishment. In other words, we understand that the optimal sales price, and the optimal wholesale price w* is negatively related to q_r.

The marginal income of retailers with externality punishment is higher than that of non-externality punishment. When there is externality punishment, it is beneficial to retailers.

Next, the overall income of online economic transactions, the manufacturer's income, and the

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retailer's income are analyzed in detail. The expected income of each member of the supply chain is shown in Table 2.

Table 2: Expected income of each member of the supply chain

	q_r=0			q_r≠0		
Model	Π_{sc}	Π_M	Π_R	Π_{sc}	Π_M	Π_R
MSPD	4.4897×10^3	3.8988×10^3	590.94	4.6275×10^3	4.0225×10^3	605
RSPD	4.4897×10^3	3.3078×10^3	1181.88	4.6275×10^3	3.4175×10^3	1210
NGPD	4.8181×10^3	3.7675×10^3	1050.56	4.9636×10^3	3.8881×10^3	1075.56
CPD	5.0807×10^3			5.2325×10^3		

In the CPD model, the expected total income of online economic transactions is the largest. In the NGPD model, the expected total income of online economic transactions is the next. In the RSPD model, the expected total return of online economic transactions is the lowest, and the expected returns of online economic transactions in the MSPD model and RSPD model are the same.

In the MSPD model, the expected return value of the manufacturer is the largest. In the NGPD model, the expected return of the manufacturer is the next. In the RSPD model, the expected return value of the manufacturer is the lowest. On the contrary, in the RSPD model, the retailer's expected return is the highest. In the NGPD model, the retailer's expected return is the next. In the MSPD model, the expected return value of retailers is the lowest. The expected income with external punishment is lower than that of the non-external punishment, which is in line with the actual situation.

According to the above analysis, the expected total income of online economic transactions is the largest in the CPD model by comparing the four models of online economic transactions. Compared with three non-centralized online economic transaction models, the expected total income of online economic transactions is the largest in the NGPD model.

When one side of the online economic transaction has an advantage in the market, it has higher opportunities to gain profits in the market. The data shows that manufacturers expect higher returns in the MSPD model than in the RSPD model, and retailers do the same.

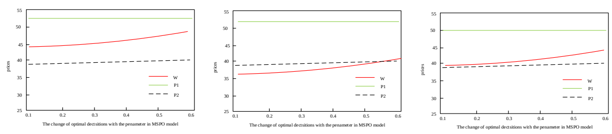

Figure 5: Relationship between decision variables and £

The figure 5 shows the change of decision variables and interruption probability of online economic transactions. The sales price P_1 of retailers, the wholesale price w of manufacturers' traditional channels, and the sales price P of direct channels increase with the increase of interruption probability, which is consistent with the previous analysis. To make up for the loss caused by interruption, manufacturers and retailers increase the wholesale price and sales price to make up for their losses.

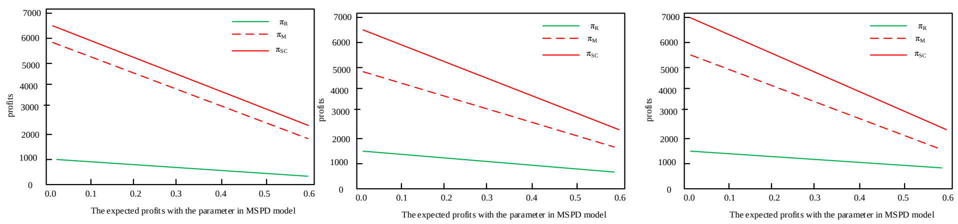

Figure 6: Relationship between expected return and £

Figure 6 also shows the changes in the expected total revenue, the expected revenue of the manufacturer, the expected revenue of the retailer, and the interruption probability of the online economic transaction. With the increase in the profit, the revenue of the manufacturer and the retailer decreases, and the total revenue of the online economic transaction also decreases.

4. Conclusion

In recent years, more manufacturing enterprises begin to adopt JIT, lean production, flexible production, and other production methods to reduce the inventory cost to a certain extent and improve the competitiveness of enterprises. However, this increases the vulnerability of the online trading system, and the company's ability to respond to emergencies is weakened. Once a sudden disaster occurs, the company's supply, reputation, and order quantity are affected. In recent years, the frequent occurrence of emergencies has brought more impact on enterprises. Therefore, enterprises need to take measures to deal with emergencies. To better deal with emergencies, enterprises usually take inventory, strategic reserve, multi-supplier, and other measures. We mainly consider the multi-supplier problem to choose backup suppliers when enterprises have unreliable suppliers. Most of the literature studies from the perspective of minimizing the total cost of enterprises. However, we consider customer service. Manufacturing enterprises' profits mainly come from main customers. Therefore, in the event of interruption, they always meet the orders of the main customers first or to the maximum extent, so as not to reduce customer satisfaction and reduce market share.

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