Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 221 (2023) 138–145

Procedia Computer Science

www.elsevier.com/locate/procedia

10th International Conference on Information Technology and Quantitative Management

Pricing decision of dual-channel supply chain with members risk-aversion under the participation of e-commerce platform

Yihua Ma[1], Meng Zhang[2], Jili Zhao[3]

School of Management Science and Engineering, Hebei University of Economics and Business, Shijiazhuang 050061, PR China

Abstract

In this paper, it considers a two-stage dual-channel supply chain model composed of a risk aversion manufacturer, a risk aversion retailer and a risk-neutral e-commerce platform. Under the condition of information symmetry, it is supposed that the manufacturer is financially constrained. Besides, the analysis is based on Stackelberg game theory. The equilibrium price without capital constraint is compared with the equilibrium price in three cases of e-commerce platform financing, bank loan financing and prepayment financing. Then the effects of risk aversion coefficients of the manufacturer and the retailer on equilibrium prices are compared in four cases. The influence of different financing rates on wholesale price, direct selling price and retail price is analyzed simultaneously.

Keywords: Dual channel supply chain; Risk aversion; Pricing decisions

1. Introduction

As of 2023, the implementation of the SME Promotion Law of the People 's Republic of China has been lasted for 20 years. Over the past two decades, government departments at all levels have introduced an array of policies to support SME financing. The problem of financing difficulties and expensive financing that has long plagued SMEs has been gradually solved, and the availability of financing has been greatly improved. The financing cost has decreased significantly, which has made important contributions to supporting small and medium-sized enterprises, ensuring employment and promoting the healthy development of the national economy. In the meantime, with the sustainable development of the Internet, in order to fully meet the needs of consumers, numerous manufacturers are working to open up online channels. Products can be sold through online channels on e-commerce platforms, or sold to consumers through traditional offline retailers. Therefore, in the dual-channel supply chain composed of three members, the manufacturer and the retailer are no longer a single cooperative relationship, but also channel

10.1016/j.procs.2023.07.020

competition. At the same time, well-developed e-commerce platforms (such as Jingdong) can both profit from the supply chain by acting as a sales intermediary, and well-funded e-commerce platforms can also provide financing for other members. At the same time, due to the complexity of the market, in the face of competition and uncertain market demand, manufacturers and retailers will make different decisions because of different risk attitudes. Therefore, when the e-commerce platform can provide financing, what impact will different financing strategy decisions have on the equilibrium pricing results? When supply chain members show a risk-averse attitude, what impact will it have on the equilibrium pricing decision of the supply chain?

As to researches of pricing and financing decisions of dual-channel supply chain with capital constraint, scholars tend to ignore the risk attitude of supply chain members and assume that they are risk neutral. Xiao[1] and Li[2] studied the influence of different financing modes on the optimal pricing decision of enterprises in dual channel supply chain under decentralized decision and centralized decision when both manufacturers and retailers are risk neutral. Guo[3], Bai[4-5], Wang[6] studied the pricing decision and financing strategy selection of supply chain with capital constraints in the face of internal financing and external financing respectively.

However, in practice, supply chain members cannot be absolutely rational and often have their own risk preferences. In reality, supply chain members often face many risks, such as information opacity, capital interruption and macro policy risks. Consequently, scholars have gradually begun to attach importance to the study of risk attitude. Li[7], Chen[8], Xue[9], Li[10], Wang[11] have used the Mean-Variance model for risk measurement, considering the pricing decision in a dual-channel supply chain when a single member is risk-averse. Cao [12], Shi[13] and Zhou[14] analyzed the influence of risk aversion on financing choice and member utility. Wang[15], Wang [16], Kim[17], Raza[18] analyzed the supply chain pricing and financing problems under mean-variance when considering the risk aversion attitude of supply chain members.

The related research mentioned above on dual channel are the traditional dual channel supply chain, which means, the secondary supply chain composed of a supplier or a manufacturer and a retailer. However, with the development of e-commerce, e-commerce platforms have gradually joined the supply chain and become one of the significant members of the supply chain. Such as Taobao, JD, Amazon, Suning Tesco and other large e-commerce platforms, which can not only provide financing for supply chain members with shortage of funds, but also supply chain members can sell through e-commerce platforms. At present, there are fewer studies about the dual-channel supply chain involving e-commerce. Zhao[19], Tang[20] and others considered that when a single member in the dual-channel supply chain faces financial constraints, make a comparative study on the basis of the bank lending financing strategy and e-commerce factoring financing strategy ; Tao Yi [21] considered the optimal pricing decision of the supply chain members and the impact on their utility when the e-commerce platform provided financing for the capital-constrained retailer or the capital-constrained supplier when the retailer and the supplier showed a risk aversion attitude. Therefore, different from the existing literature on the dual-channel financing of e-commerce platforms, this article studies the effects of capital-constrained manufacturers on the optimal pricing in three cases of e-commerce financing, bank loan financing and prepayment financing when considering the risk aversion of both the manufacturer and the retailer. Section 2 introduces the basic model and the basic process of supply chain. Section 3 describes the model without financial constraints. Section 4 describes three models under financing constraints and the results are compared and analyzed. Section 5 uses specific values to verify the previous results. In the section 6, the conclusion is summarized and elaborated.

2. Model description and basic assumptions

This paper considers a dual-channel supply chain composed of a manufacturer, a retailer and an e-commerce platform. The manufacturer produces the same product and sells it through the direct channel by the e-commerce platform and the traditional channel by the retailer. In the online direct channel, the manufacturer needs to pay a certain proportion fees to the e-commerce platform. The manufacturer is the leader of the Stackelberg game, and the retailer is the follower. At the same time, assuming that the manufacturer is capital-constrained, while the retailer and the e-commerce platform are fully funded. In order to solve the problem of capital constraints, the manufacturer can choose among three financing methods: e-commerce platform financing, bank loan financing and prepayment financing.

Table1.Notations

parameters	parameter declaration
d_i (i=e,r)	Demand for channel
d	Market demand
p_e^i (i=N,E,B,A)	Direct sales price
p_r^i (i=N,E,B,A)	Retail price
c	Unit cost
δ	Charge ratio of e-commerce platform，0<δ<0.1
w^i (i=N,E,B,A)	Wholesale price
θ	Direct channel market share，0＜θ＜1
λ	Cross price elasticity coefficient,0＜λ＜1
k_i (i=m,r)	Coefficient of risk-aversion
r_i (i=e,b,a)	Lending rate
L_i (i=e,b,a)	Loan amount
Π_i (i=m,e,r)	Profits for supply chain members
U_i (i=m,e,r)	Utility for supply chain members

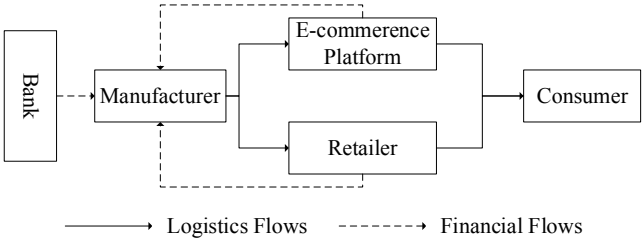

Fig1.Supply chain operation flow chart

Assuming that the capital market is in a state of complete competition, the risk-free interest rate is zero; the decision maker is completely rational, and the information between the members of the supply chain is completely symmetrical. The products made by the manufacturer sell both in the direct channel and the traditional channel. Suppose the total market demand is $\tilde{d}$, $\tilde{d} = d + \varepsilon$,where ε is a random variable. Here d is the average demand of the potential market and $\varepsilon \sim N(0, \sigma^2)$ .The market demand of direct channel is: $d_e = \theta\tilde{d} - p_e + \lambda p_r$.

The market demand for retail channels is: $d_r = (1-\theta)\tilde{d} - p_r + \lambda p_e$ .The manufacturer 's expected profit function is: $E(\pi_m) = (w-c)\times d_r + (p_e - c)\times d_e \times (1-\delta) - Lr$ .The retailer 's expected profit function is: $E(\pi_r) = (p_r - w)\times d_r$. The expected profit function of e-commerce platform is: $E(\pi_e) = \delta(p_e - c)\times d_e + L_e \times r_e$.

The E-commerce platform and the retailer have sufficient funds, but the manufacturer faces financial constraint. Further assume that the initial capital of the manufacturer 's capital constraint is 0.

In 1959, Markowitz proposed the mean-variance method for risk measurement. The goal of the mean-variance method is to achieve profit as high as possible and the lowest possible uncertainty risk, and to achieve the best balance between these two mutually restrictive goals. In this paper, the mean-variance method is used to calculate the utility. And it is assumed that the e-commerce platform is risk neutral, while the manufacturer and the retailer are risk-averse. Then the utility measure formula of manufacturer and supplier is $U_i = E(\pi_i) - k_i\sqrt{\mathrm{var}(\pi_i)}$. k_i represents the risk aversion coefficient of the manufacturer or retailer. According to Arrow-Pratt conclusion and Cao Yugui [22]'s research method, the part of $k_i\sqrt{\mathrm{var}(\pi_i)}$ is equivalent to the risk cost of supply chain members. And the greater k_i , the higher the degree of risk aversion of manufacturers or retailers.

3. Pricing decision model of supply chain without capital constraint

At this time, the manufacturer has sufficient funds to produce products. Each member of the supply chain produces from the perspective of maximizing their own interests. The decision order of enterprises in the supply chain is as follows: the manufacturer first determines the wholesale price of the product and the direct selling price through the e-commerce platform, and then the retailer determines its own retail price. It is assumed that the proportion of intermediary fees charged by the e-commerce platform δ is an exogenous variable.

The utility function of supply chain members is as follows:

$$U_m^N = (w^N - c)\times[(1-\theta)d - p_r^N + \lambda p_e^N] + (p_e^N - c)\times[\theta d - p_e^N + \lambda p_r^N]\times(1-\delta)$$
$$-k_m[(w^N - c)(1-\theta) + (p_e^N - c)(1-\delta)\theta]\sigma$$

$$U_r^N = (p_r^N - w^N)\times[(1-\theta)d - p_r^N + \lambda p_e^N] - k_r[(p_r^N - w^N)(1-\theta)]\sigma$$

$$U_e^N = \delta(p_e^N - c)\times(\theta d - p_e^N + \lambda p_r^N)$$

4. Dual-channel supply chain financing strategy under capital constraint

4.1. E-commerce platform financing

When the manufacturer's capital is constrained, the amount of loan financing to the e-commerce platform is all used for production. The e-commerce platform sets the loan interest rate r_e and provides funds to the manufacturer. After the sales period ends, the manufacturer repays the principal and interest to the e-commerce platform, regardless of the manufacturer 's bankruptcy risk and product residual value. The order of decision-making is consistent with that without financial constraints.

The utility function of supply chain members is as follows:

$$U_m^E = (w^E - c)\times[(1-\theta)d - p_r^E + \lambda p_e^E] + (p_e^E - c)\times[\theta d - p_e^E + \lambda p_r^E]\times(1-\delta)$$
$$-c[d - (1-\lambda)(p_e^E + p_r^E)]r_e - k_m[(w^E - c)(1-\theta) + (p_e^E - c)(1-\delta)\theta - cr_e]\sigma$$

$$U_r^E = (p_r^E - w^E)\times[(1-\theta)d - p_r^E + \lambda p_e^E] - k_r[(p_r^E - w^E)(1-\theta)]\sigma$$

$$U_e^E = E(\pi_e^N) = \delta(p_e^N - c)\times(\theta d - p_e^N + \lambda p_r^N) + c[d - (1-\lambda)(p_e^E + p_r^E)]r_e$$

4.2. Bank lending financing

Similarly, when manufacturers face financial constraints, they can also choose to borrow from banks for financing. The bank sets the loan interest rate as r_b. After the sales period, the manufacturer returns the principal and interest to the bank.

The utility function of supply chain members is as follows:

$$U_m^B = (w^B - c)\times[(1-\theta)d - p_r^B + \lambda p_e^B] + (p_e^B - c)\times[\theta d - p_e^B + \lambda p_r^B]\times(1-\delta)$$
$$-c[d - (1-\lambda)(p_e^B + p_r^B)]r_b - k_m[(w^B - c)(1-\theta) + (p_e^B - c)(1-\delta)\theta - cr_b]\sigma$$

$$U_r^B = (p_r^B - w^B)\times[(1-\theta)d - p_r^B + \lambda p_e^B] - k_r[(p_r^B - w^B)(1-\theta)]\sigma$$

$$U_e^B = E(\pi_e^B) = \delta(p_e^B - c)\times(\theta d - p_e^B + \lambda p_r^B)$$

4.3. Advance payment financing

The manufacturer requires the retailer to pay in advance for financing, and give the retailer advance payment discount r_a for incentives. It is assumed that the value of the advance payment discount coefficient is within a certain range, which is determined by the market, and the specific value is generally agreed by the manufacturer and the retailer in reality. First, the amount of financing loans is determined before formal production and all of them are used for production. After the production, the manufacturer decides the wholesale price and the direct selling price. The retailer is provided with products with price discounts, and then the retailer purchases the remaining goods at the wholesale price and determines the retail price.

The utility function of supply chain members is as follows:

$$U_m{}^A = (w^A - c)\times[(1-\theta)d - p_r{}^A + \lambda p_e{}^A] + (p_e{}^A - c)\times[\theta d - p_e{}^A + \lambda p_r{}^A]\times(1-\delta)$$
$$-c[d-(1-\lambda)(p_e{}^A + p_r{}^A)]r_a - k_m[(w^A - c)(1-\theta) + (p_e{}^A - c)(1-\delta)\theta - cr_a]\sigma$$

$$U_r{}^A = (p_r{}^A - w^A)\times[(1-\theta)d - p_r{}^A + \lambda p_e{}^A] + c[d-(1-\lambda)(p_e{}^A + p_r{}^A)]r_a$$
$$-k_r[(p_r{}^A - w^A)(1-\theta) + cr_a]\sigma$$

$$U_e{}^A = E(\pi_e{}^A) = \delta(p_e{}^A - c)\times(\theta d - p_e{}^A + \lambda p_r{}^A)$$

4.4. Comparative analysis

According to the obtained optimal solution without capital constraints and under different financing conditions, the following analysis can be carried out:

$$\frac{\partial(w^i)}{\partial(k_m)}<0,\frac{\partial(p_e{}^i)}{\partial(k_m)}<0,\frac{\partial(p_r{}^i)}{\partial(k_m)}<0 \qquad \frac{\partial(w^i)}{\partial(k_r)}>0,\frac{\partial(p_e{}^i)}{\partial(k_r)}>0,\frac{\partial(p_r{}^i)}{\partial(k_r)}<0 \qquad (i=E,B,A)$$

$$\frac{\partial(w^E)}{\partial(r_e)}>0,\frac{\partial(p_e{}^E)}{\partial(r_e)}>0,\frac{\partial(p_r{}^E)}{\partial(r_e)}>0 \quad \frac{\partial(w^B)}{\partial(r_b)}>0,\frac{\partial(p_e{}^B)}{\partial(r_b)}>0,\frac{\partial(p_r{}^B)}{\partial(r_b)}>0 \quad \frac{\partial(w^A)}{\partial(r_a)}>0,\frac{\partial(p_e{}^A)}{\partial(r_a)}>0,\frac{\partial(p_r{}^A)}{\partial(r_a)}>0$$

The first order derivatives of w^i, $p_e{}^i$ and $p_r{}^i$ with respect to k_m are calculated respectively, and the relationship with 0 is judged. The result is shown as above. The risk aversion coefficient of the manufacturer k_m is negatively correlated with w^i, $p_e{}^i$ and $p_r{}^i$. The retailer 's risk aversion coefficient k_r is negatively correlated with $p_r{}^i$, but positively correlated with w^i and $p_e{}^i$.

However, under three different financing modes, the change of wholesale price, direct selling price and retail price is consistent with the change of financing interest rate. The higher the financing interest rate, the higher w^i, $p_e{}^i$ and $p_r{}^i$.

Then it is supposed that financing interest rates $r = r_b = r_e = r_a$.

It is concluded that:

$w^{N*} - w^{E*}(w^{B*}) < 0$, $w^{N*} - w^{A*} < 0$, $p_e{}^{N*} - p_e{}^{E*}(p_e{}^{B*}) < 0$, $p_e{}^{N*} - p_e{}^{A*} < 0$, $p_r{}^{N*} - p_r{}^{E*}(p_r{}^{B*}) < 0$, $p_r{}^{N*} - p_r{}^{A*} < 0$.

Therefore, the equilibrium w^{N*} 、 $p_e{}^{N*}$ and $p_r{}^{N*}$ without capital constraint are lower than the equilibrium price in each financing case.

$w^{A*} > w^{E*}(w^{B*})$, $p_e{}^{A*} > p_e{}^{E*}(p_e{}^{B*})$, $p_r{}^{A*} < p_r{}^{E*}(p_r{}^{B*})$

Under the prepayment financing mode, the equilibrium w^{A*} and $p_e{}^{A*}$ are higher than the equilibrium price of e-commerce financing and bank lending financing. But $p_r{}^{A*}$ is lower than $p_r{}^{E*}(p_r{}^{B*})$.

5. Example analysis

In order to intuitively see the effectiveness of the model and facilitate the comparison of the expected profit and utility of various types of dual channels, a numerical example is used for comparative analysis. It is assumed that the

total market demand of the dual-channel supply chain is d=100, the commission ratio charged by the platform is =0.05, the unit cost of the manufacturer is c=10, the market share of the direct channel is θ= 0.6, the cross-price elasticity coefficient is λ= 0.5, and the financing interest rate is $r=r_a=r_e=r_b=0.4$.

Let $k_r=1$, it can be seen from the calculation results that as the km continues to increase, that is, as the manufacturer 's risk aversion continues to increase, the wholesale price, direct selling price, and retail price changes without capital constraints and under three financing conditions.

Table2 The impact of manufacturer risk aversion on pricing

k_m	w^N	$w^E(w^B)$	w^A	p_e^N	$p_e^E(p_e^B)$	p_e^A	p_r^N	$p_r^E(p_r^B)$	p_r^A
0	70.8975	72.9235	73.7409	67.8253	69.9211	69.9310	77.5115	79.1533	78.3177
0.5	66.5451	68.5711	69.3885	64.6688	66.7646	66.7745	74.3913	76.0331	75.1975
1	62.1986	64.2246	65.0420	61.5124	63.6082	63.6181	71.2711	72.9129	72.0733
1.5	57.8521	59.8781	60.6955	58.3560	60.4518	60.4617	68.1509	69.7927	68.9571
2	53.5056	55.5316	56.3490	55.1996	57.2954	57.3053	65.0307	66.6725	65.8369

According to the table2, it can be seen that with the continuous increase of km, the wholesale price, direct selling price and retail price are increasing in all cases. That is, the risk aversion coefficient k_m of the manufacturer is positively correlated with the wholesale price, direct selling price and retail price. Besides, when the manufacturer has the same degree of risk aversion, w^N is the lowest, and w^A is the highest. When the financing interest rate is consistent, the wholesale price of e-commerce financing is equal to the wholesale price of bank lending financing, $w^E=w^B$. The relationship between the direct selling price under different financing modes is consistent with the wholesale price. However, the relationship between retail prices under different financing models is different. According to the data can be seen that p_r^N is the lowest is unquestionable. But p_r^A is lower than $p_r^E(p_r^B)$.

Identically, let $k_m=1$.With the increasing degree of risk aversion of the retailer, the changes of wholesale price, retail price and direct selling price can be obtained as following.

Table3 The impact of retailer risk aversion on pricing

k_r	w^N	$w^E(w^B)$	w^A	p_e^N	$p_e^E(p_e^B)$	p_e^A	p_r^N	$p_r^E(p_r^B)$	p_r^A
0	59.6805	61.7065	62.5239	61.4816	63.5774	63.5873	72.5028	74.1446	73.3090
0.5	60.9396	62.9656	63.7830	61.4970	63.5928	63.6027	71.8870	73.5288	72.6932
1	62.1986	64.2246	65.0420	61.5124	63.6082	63.6186	71.2711	72.9129	72.0773
1.5	63.4576	65.4836	66.3010	61.5278	63.6236	63.6335	70.6552	72.2970	71.4614
2	64.7166	66.7426	67.5600	61.5433	63.6391	63.6490	70.0694	71.6812	70.8456

From the results of table 3, with the increase of k_r, the wholesale price and direct selling prices are increasing, that is, the wholesale price and direct selling price are positively correlated with k_r. On the contrary, the retail price shows a decreasing trend, which is negatively correlated with k_r.

Similarly, the relationship between wholesale prices is $w^N < w^E = w^B < w^A$; the relationship between direct selling prices is $p_e^N < p_e^E = p_e^B < p_e^A$; the relationship between retail prices is different, which is embodied in $p_r^N < p_r^A < p_r^E = p_r^B$.

Then, taking the wholesale price w as an example, the change of wholesale price with financing interest rate is analyzed.

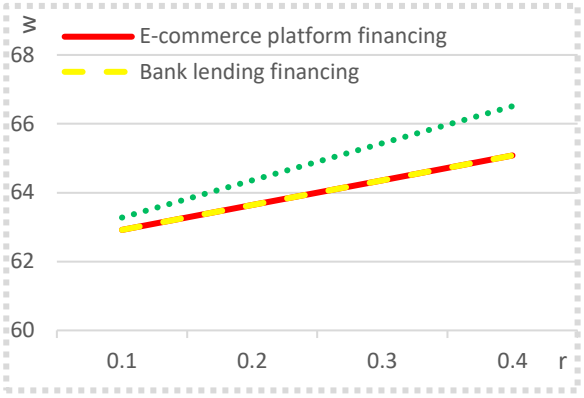

Fig2.The change of w with financing interest rate r

According to the Fig2, it is easy to see that as the financing interest rate continues to increase, the wholesale price w under the three financing methods continues to increase. And when $r_e = r_b$, the wholesale prices under the two financing modes are equal. The analysis of direct selling price and retail price is the same as wholesale price, so it is no longer repeated.

6. conclusion

This paper considers the dual-channel supply chain with the participation of e-commerce platform, and in the supply chain, both the manufacturer and the retailer show the characteristics of risk aversion. It analyzes and compares the equilibrium prices under the three modes of e-commerce financing, bank loan financing and early payment financing, and draws the following conclusions:

(1) Regardless of the financing mode chosen by the capital-constrained manufacturer, the retail price, direct selling price and wholesale price decrease with the increase of the manufacturer 's risk aversion. In contrast, as the retailer 's risk aversion increases, the retail price decreases, but the wholesale price and the direct price increase. Therefore, the greater risk aversion the retailer, the more benefits the manufacturer will acquire. The same is true for retailers.

(2) When the financing interest rate is equal, the size of the wholesale price is: $w^B=w^E<w^A$; the size of the direct selling price is: $p_e^B=p_e^E<p_e^A$; the size of the retail price is: $p_r^B=p_r^E>p_r^A$.

(3) No matter what kind of financing mode, because the emergence of the financing process will lead to an increase in the cost of manufacturers, resulting in the whole chain of wholesale prices, direct selling prices, retail prices have increased to varying degrees.

(4) No matter what kind of financing model, with the continuous improvement of financing interest rates, will lead to higher wholesale prices, direct selling prices and retail prices.

From the perspective of management, the enlightenment that can be obtained is that manufacturers are more willing to cooperate with risk-averse retailers, and manufacturers will increase market demand by reducing wholesale prices, thereby making them more profitable; the more risk-averse the manufacturer, the negative impact on the profit of the entire supply chain.

At the same time, there are still limitations in the research of this paper. For instance, it is assumed that the initial capital of the manufacturer is 0. It is ignored that the influence of the initial capital. Moreover, this paper assumes that the manufacturer and the retailer are information symmetric, and there may be some information that is private in reality. Future research can start from other aspects: such as considering the situation of information asymmetry, the manufacturer’s risk aversion or the retailer 's risk aversion is its private information; we can study other financing situations such as equity financing and compare the results under different financing methods; it can also be considered that there are two retailers, and there is competition between retailers.

References

[1] Xiao Xiao Xiao, Luo Jianwen. Dual-channel supply chain financing strategy for capital-constrained manufacturers [J]. *Journal of Systems Management*, 2016,25 (01): 121-128 + 138 (in Chinese)

[2] Li and Wei. Research on pricing strategy of dual-channel supply chain considering risk aversion of service and return [J] *Logistics Engineering and Management*, 2023,45 (01): 59-64(in Chinese)

[3] Guo Jinsen, Zhou Yongwu. Research on the financing strategy of dual-channel supply chain with uneconomical production scale [J].*Business Research*, 2018, No.493 (05) : 142-151.(in Chinese)

[4] Bai, Zheng, Wang. Research on dual-channel production and financing decision-making of capital-constrained manufacturing enterprises [J]*Computer simulation*, 2023,40 (01): 319-325 (in Chinese)

[5] Bai Shizhen, Jia Xuelian. Research on the operation strategy of capital-constrained dual-channel supply chain of fresh agricultural products [J] *China Management Science*: 1-13(in Chinese)

[6] Wang Wenlong, Wang Zihao, Zhang Suxian, Liu Qi. Research on dual-channel supply chain financing strategy considering retailer loss aversion under random demand [J] *Management Review*: 1-13(in Chinese)

[7] Li B, Hou P W, Chen P, et al. Pricing strategy and coordination in a dual channel supply chain with a risk-averse retailer[J].*International Journal of Production Economics*, 2016, 178(Aug.):154-168.

[8] Chen X, Hao G, Li L. Channel coordination with a loss-averse retailer and option contracts[J]. *International Journal of Production Economics*, 2014,150:52-57.

[9] Xue W, Choi T M, Ma L. Diversification strategy with random yield suppliers for a mean-variance risk-sensitive manufacturer[J]. *Transportation Research Part E: Logistics and Transportation Review,* 2016, 90: 90-107.

[10] Li Bo, Wang Rufeng, Chen Weichun. Research on the impact of risk-averse manufacturers on supply chain decision-making strategies under e-commerce [J]*Journal of Management Engineering*, 2019,33 (02): 173-179(in Chinese)

[11] Wang Heping, Yan Xiaochen, Zhao Dan, Li Yan. Research on pricing decision of dual-channel supply chain considering risk aversion and free riding [J]*Operation research and management*: 1-8(in Chinese)

[12] Cao Zonghong, Zhang Chengtang, Zhao Ju, Min Jie. Research on financing strategies and channel selection of risk aversion manufacturers based on capital constraints [J]*China Management Science*, 2019,27 (06): 30-40(in Chinese)

[13] Shi and Sun. Pricing decision of dual-channel supply chain considering retailer 's capital constraints under supplier risk aversion [J]*Prediction*, 2019 (2): 90-96(in Chinese)

[14] Zhou Yongwu, Zhang Xiong, Li Lu. Pricing and financing decisions of dual-channel supply chain with financial constraints [J]. *Journal of Systems Engineering*, 2020,35 (05): 670-688(in Chinese)

[15] Wang Daoping, Gu Chunxiao, Zhang Boqing. Research on pricing decision of dual-channel supply chain under risk aversion and information asymmetry [J]. *Industrial Engineering and Management*, 2016,21 (04): 20-25 + 34(in Chinese)

[16] Wang Hong, Zhou Jing. The impact of competition and risk aversion on dual-channel supply chain decisions [J]*Management Science*, 2010,23 (01): 10-17(in Chinese)

[17] Kyoung-Kuk Kim,Kun Soo Park. Transferring and sharing exchange-rate risk in a risk-averse supply chain of a multinational firm[J]. *European Journal of Operational Research*,2014,237(2).

[18] Syed Asif Raza,Srikrishna Madhumohan Govindaluri. Pricing strategies in a dual-channel green supply chain with cannibalization and risk aversion[J]. *Operations Research Perspectives*,2019,6(C).

[19] Zhao Lin, Zhang Keyong, Gao Yin. A dual-channel supply chain financing strategy with capital constraints for manufacturers [J]*Operation and management*: 1-10(in Chinese)

[20] Tang Ting, Xu Haiyan, Zhang Zhichao. Online dual-channel supply chain operation strategies under different financing modes [J]*China Management Science*: 1-11(in Chinese)

[21] Tao Yi, Yang Ruisi, Lin Qiang, Wang Fan. E-commerce supply chain financing and pricing decision model considering competition and risk aversion behavior [J]*China Management Science*: 1-15(in Chinese)

[22] Cao Yugui. Principal-agent analysis in third-party logistics under asymmetric information [J]. Journal of Science and Engineering, 2007, 21 (2): 74-77. (in Chinese)