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A Study on Purchasing Optimisation for Cross-border E-commerce Enterprises under Uncertainties

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Short Research Paper

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Abstract: In recent years, cross-border e-commerce has become a new economic growth point for many countries. However, in the purchasing process, most cross-border e-commerce enterprises still use stocking strategies based on general experience. Since goods need to be reordered immediately when they are out of stock, a lack of a scientifically-based purchasing plan may result in excessive inventory and a low inventory turnover rate. Thus, the ability to determine appropriate order quantity under uncertain cross-border market demands is key to improving the inventory control of cross-border e-commerce enterprises. To ensure the quality of cross-border e-commerce products and maximise profits, it is crucial to formulate an effective and practical purchasing strategy. Based on existing research, this paper examines a cross-border e-commerce purchasing strategy under uncertainty by using the newsvendor model and setting expected profit maximisation as the goal. Specifically, this paper explores the optimal purchasing strategy for cross-border e-commerce products under discrete and continuous stochastic demands.

Keywords: cross-border e-commerce, ordering strategy optimisation, newsvendor model

1. INTRODUCTION

At present, the definition of cross-border e-commerce that is well accepted by the academic community is international business activities in which trading entities belonging to different customs borders complete transactions, payments and settlements through e-commerce platforms, and deliver goods through cross-border logistics services.

China's cross-border e-commerce trade volume has maintained an upward trend in recent years due to increasing consumption upgrading in numerous countries, the significant improvement of international logistics services and the continuous advancement of cross-border payment channels. Cross-border e-commerce has become an important driving force for the recovery of China's foreign trade. Currently, the biggest challenge faced by cross-border e-commerce businesses is inefficient purchasing processes. The purchasing pattern of cross-border e-commerce is characterised by long delivery periods, large batches and large transaction amounts, while that of traditional businesses is characterised by short delivery periods, small batches, large variety of goods and high trading frequency. Due to long transportation distances, long procurement lead times and large fluctuations in product demand, the biggest risks of cross-border e-commerce enterprises lie in problems caused by the over- or undersupply of goods.

Real-life business conditions are constantly changing. This study will explore the purchasing problems that cross-border e-commerce enterprises face under uncertainties, so as to provide such companies with valuable suggestions on purchasing optimization. By using the newsboy model, an optimal ordering plan is formulated to reduce inventory and stock-out costs, increase expected revenue, and achieve the ultimate goal of improved overall competitiveness.

1.1 Importance of purchasing strategy optimisation for cross-border e-commerce enterprises

The purchasing problems shared by cross-border e-commerce enterprises are marked by certain

characteristics. First, to reduce production costs, upstream suppliers of cross-border e-commerce enterprises usually have a minimum order quantity for each category of goods. Second, as these businesses have a large number of SKUs and high sales demand, the purchasing pattern features large order quantities, stable ordering cycles, a wide variety of products and small batches. Third, shipping times are long, and customs clearance and inspection times fluctuate. To avoid running out of stock, cross-border e-commerce enterprises usually place orders with suppliers at a quantity higher than the actual sales demand. Last, arrival times and quantities of goods are uncertain. In the case of a sudden increase in sales, a supplier may fail to deliver the required goods in one batch on time.

1.1.1 Theoretical significance

Among existing research on purchasing strategies of cross-border e-commerce businesses, most studies have focused on inventory control of the entire supply chain. As time goes on, purchasing strategies have expanded to areas such as diversified buying channels and multi-stage ordering portfolios. To view cross-border e-commerce purchasing strategies from a scientific perspective, and to improve both consumption quality of overseas consumers and business operating profits, this paper aims to find the most effective and practical purchasing strategy for cross-border e-commerce enterprises under uncertain market demands. Moreover, factors influencing profit are also studied to provide comprehensive and helpful suggestions for such enterprises. Therefore, this paper hopes to broaden current research on purchasing strategies.

1.1.2 Practical significance

This paper aims at providing decision-making references and management suggestions for cross-border e-commerce enterprises, to help them improve their customer service quality and management systems. Demand forecasting methods which are scientific, effective, standardised and practical are critical for increasing operating profits, reducing inventory loss, minimising inventory oversupply, saving social resources, and improving customer service ability and satisfaction.

2. LITERATURE REVIEW

Purchase quantity has a great effect on an enterprise’s various costs and bottom line. Therefore, establishing an appropriate ordering amount is crucial from both an economic and practical standpoint. The newsboy model is often used to determine the ideal order quantity. It has been studied by many researchers, such as Cachon, who systematically examined how companies can maximize their expected returns under uncertainties by constructing a newsboy model to obtain the optimal order quantity under various circumstances.

Furthermore, many scholars have realized the importance of considering the impact of uncertain factors on both the demand and supply sides of purchasing decisions, and have focused their attention on ordering models under uncertain procurement lead-times and unpredictable supply shipment arrival times. Among related studies, most have based their work on random fuzzy theory. Many scholars, such as Chang and Yao, have explored ordering models that combine randomness and fuzziness, i.e., when the fuzzy variable is customer demand, or when the demands within the procurement lead-time are a random fuzzy variable. In another study, Yu Chunyun et al. used the random fuzzy demand expectancy theory to establish a random fuzzy programming model for both single and multiple products, with the goal of maximizing expected value.

By utilizing existing research and applying theories to real-life scenarios, this study aims to explore the purchasing processes of cross-border e-commerce enterprises. Based on related characteristics, an ordering model is created to guide cross-border e-commerce companies to form a systematic and reasonable ordering plan, reduce inventory costs and improve capital utilization.

3. INTRODUCTION OF THE NEWSVENDOR MODEL UNDER UNCERTAINTIES

The research method adopted in this paper is mainly quantitative analysis, supplemented by qualitative analysis. The characteristics, nature and influencing factors of cross-border e-commerce purchasing strategies are explained from a real-world perspective, and the newsvendor model and probability theory are applied to examine the proposed strategy under uncertain demands.

As a classic model addressing single-period inventory problems, the newsvendor model can be used to obtain the maximum expected profit under uncertainties, which fits the demand uncertainty of cross-border e-commerce products studied in this paper. In this way, the optimal order quantity of discrete and continuous cases is obtained, and the degree of influence of each variable is further compared and examined through numerical analysis. Finally, suggestions are given to cross-border e-commerce enterprises with respect to purchasing strategy.

The traditional newsvendor problem is also known as the single-period inventory problem. In the early years of business management research, the newsvendor model was applied to resolve retailers' purchase quantity problems to maximise profit under uncertain demand [10]. The model has since attracted great scholarly attention since 1888, when the famous economist Edgeworth [11] used the newsvendor model to find the ideal reserve amount banks should keep. The model has a simple framework and can deal real-life problems related to inventory, economy and production, such as the setting of safety stocks, one-time sales, and demand estimations during peak seasons .

In practical application, the newsvendor model, based on statistical analysis of past market demand, uses the order quantity Q, sales volume x, sales price a, wholesale price b, bargain price c and other parameter variables to maximise the profits of retailers or manufacturers.

The expected profit model of the newsvendor model is generally expressed as follows:

$$E(\pi) = \int_0^Q [(a-b)x - (b-c)(Q-x)]f(x)dx + \int_Q^\infty (a-b)Qf(x)dx$$

By calculating the second derivative with respect to inventory Q using the formula above, we have:

$$\frac{d^2E(\pi)}{dQ^2} = -(a\text{-}c)f(Q) < 0$$

Hence, the expected profit is a convex function with respect to Q, and the optimal purchase quantity has a unique solution, which is:

$$Q^* = F^{-1}((a-b)/(a-c))$$

As cross-border e-commerce enterprises are faced with uncertain overseas market demands and increased risks of product damage from transportation and customs clearance processes, they need to determine the optimal purchase quantity before initialising the transaction. The newsvendor model is suitable for solving the purchasing problem under uncertainties; and therefore, it is used in this paper to determine the best purchase quantity for cross-border e-commerce businesses.

4. RESEARCH ON PURCHASING STRATEGY OPTIMISATION FOR CROSS-BORDER E-COMMERCE ENTERPRISES UNDER UNCERTAINTIES

Restrained by trade policies, political environments and transportation regulations of different countries, uncertain consumer demand is a common market problem faced by many cross-border e-commerce enterprises, which has also given rise to unknown risks and difficulties for such businesses in making purchasing decisions.

4.1 The problem in detail

In the sales process of cross-border e-commerce products, since market demand is stochastic and subject to

consumer preferences, festivals, customs, etc., there may be oversupply or undersupply, which may affect business profits. Therefore, before purchasing, cross-border e-commerce enterprises usually take historical sales as a reference to predict market demands for next year. In the sales process, the enterprise first buys Q products at wholesale price b, and sets the retail price of the product as a. Then, at the end of the period, if the sales volume is lower than the purchase quantity, the remaining products will be sold at bargain price c (c<b). If a certain product is out of stock, there will be a shortage cost.

4.2 Model symbols and assumptions

4.2.1 Assumptions

1. The inventory is 0 when the first purchase is placed;

2. Within the sales cycle, the demand x of the cross-border e-commerce product is a random non-negative variable;

3. The seller, that is, the cross-border e-commerce enterprise, is rational, and its risk preference is neutral.

4.2.2 Symbol description

a: the retail price per unit of the cross-border e-commerce product;

b: the wholesale price per unit of the cross-border e-commerce product;

c: the bargain price per unit of the cross-border e-commerce product (a>b>c);

x: the daily market demand of the cross-border e-commerce product, which is a random variable, and its probability is P(x);

Q: the purchase quantity of the cross-border e-commerce product;

f(x): the density function of the demand of the cross-border e-commerce product;

F(x): the distribution function of stochastic demand of the cross-border e-commerce product, and the inverse function is expressed by F-1 (x);

π: the sales revenue of the cross-border e-commerce product;

C: the sales loss, including C1 unsalable loss and C2 out of stock loss.

4.3 Purchasing strategy under discrete demand

4.3.1 Purchasing model under discrete demand

When the purchase quantity is Q, there are two kinds of losses:

(1) When the supply exceeds the demand (Q≥x), the excess product cannot be sold, and the expected value of loss is

$$C_1 = (\text{b-c}) \sum (Q - x) P(x)$$

(2) When the supply exceeds the demand (Q<x), there is the loss of sales opportunities due to shortage of stock, and the expected value of loss is

$$C_2 = (\text{a-b}) \sum (x - Q) P(x)$$

And the total loss is

$$\text{C=C}_1\text{+C}_2\text{=(b-c)} \sum_{x=0}^{Q} (Q - x)\, P(x) + \text{(a-b)} \sum_{x=Q+1}^{\infty} (x - Q)\, P(x)$$

If the optimal purchase quantity is Q *, then to satisfy

$$C(Q^*) \le C(Q^*+1) \qquad (4\text{-}1)$$

$$C(Q^*) \le C(Q^*-1) \qquad (4\text{-}2)$$

By substituting into formula 4-1, we have

$$(\text{b-c})\sum_{x=0}^{Q^*}(Q^*-x)\,P(x)+(\text{a-b})\sum_{x=Q^*+1}^{\infty}(x-Q^*)\,P(x)$$

$$\leq(\text{b-c})\sum_{x=0}^{Q^*+1}(Q^*-x+1)\,P(x)+(\text{a-b})\sum_{x=Q^*+2}^{\infty}(x-Q^*-1)\,P(x)$$

Similarly, from formula 4-2, we have

$$\sum_{x=0}^{Q^*-1}P(x)\leq\frac{\text{a-b}}{\text{a-c}},$$

Combining the above, we see that

$$\sum_{x=0}^{Q^*-1}P(x)\leq\frac{\text{a-b}}{\text{a-c}}\leq\sum_{x=0}^{Q^*}P(x) \qquad (4\text{-}3)$$

The optimal purchase quantity under discrete demand can be determined by formula 4-3, where (a-b)/(a-c) is the critical value.

4.3.2 Example analysis I

The daily demand of product A sold by a cross-border e-commerce enterprise is between 30 pieces and 40 pieces. The retail price a = 10 yuan / piece, the wholesale price b = 6 yuan / piece, and the bargain price c = 4 yuan / piece. The probability distribution of demand x is shown in Table 4-1.

Table 4-1 Probability distribution of the demand of product A.

Requirement x	30	31	32	33	34	35	36	37	38	39	40
P（x）	0.08	0.10	0.12	0.14	0.17	0.12	0.10	0.08	0.04	0.03	0.02

According to formula 4-3

$$\sum_{x=30}^{Q^*-1}P(x)\leq\frac{10\text{-}6}{10\text{-}4}\leq\sum_{x=30}^{Q^*}P(x)$$

We have

$$\sum_{x=30}^{Q^*-1}P(x)\leq 0.67\leq\sum_{x=30}^{Q^*}P(x)$$

Since P(30) +P(31) +P(32) +P(33)+P(34) =0.61<0.67; P(30) +P(31) +P(32) +P(33) +P(34) +P（35）=0.73>0.67, the optimal purchase quantity Q* =35 (pieces).

4.4 Purchasing strategy under continuous demand

The above analysis only considers the purchase quantity problem under discrete stochastic demand; however, in many cases, continuous demand distribution is more in line with actual demand. Therefore, the purchasing strategy under continuous demand is analysed in the next part.

4.4.1 Purchasing model under continuous demand

Considering undersupply and oversupply, the daily sales profit of a cross-border e-commerce product is

$$\pi=\begin{cases}(a-b)Q & ,x>Q\\ (a-b)x-(b-c)(Q-x), & x<Q\end{cases} \qquad (4\text{-}4)$$

$$E(\pi)=\int_0^Q[(a-b)x-(b-c)(Q-x)]f(x)dx+\int_Q^{\infty}(a-b)Qf(x)dx \qquad (4\text{-}5)$$

To calculate the first derivative of Q with respect to the expected profit function E(π) of the cross-border product

$$\frac{\mathrm{dE}(\pi)}{dQ} = (\mathrm{a\text{-}b})\int_Q^{\infty} f(x)dx - (b-c)\int_0^Q f(x)dx \qquad (4\text{-}6)$$

Let formula 4-6 = 0, then

$$F(Q) = \left(\frac{\mathrm{a\text{-}b}}{\mathrm{a\text{-}c}}\right) \qquad (4\text{-}7)$$

To calculate the second derivative of Q with respect to the expected profit function E(π)

$$\frac{d^2E(\pi)}{dQ^2} = -(\mathrm{a\text{-}c})f(Q) \qquad (4\text{-}8)$$

Since

$\frac{d^2E(\pi)}{dQ^2}<0$,

π(Q) is a convex function with respect to Q. The optimal purchase quantity Q* of the cross-border e-commerce product exists and is unique, and can be obtained from formula 4-7

$Q^*=F^{-1}\left(\frac{\mathrm{a\text{-}b}}{\mathrm{a\text{-}c}}\right)$。

4.4.2 Example analysis II

The daily demand of product A sold by a cross-border e-commerce enterprise is between 30 pieces and 40 pieces. The retail price a = 10 yuan / piece, the wholesale price b = 6 yuan / piece, and the bargain price c = 4 yuan / piece. The demand is a random variable and follows the normal distribution of x~N (33.99, 2.48).

$$\mathrm{F(x)} = \frac{\mathrm{a\text{-}b}}{\mathrm{a\text{-}c}} = \frac{10-6}{10-4} \approx 0.67,$$

According to the standard normal distribution table, the corresponding value of 0.67 is 0.44, then (Q-μ)/σ=0.44, Q=35.08, so the optimal purchase quantity of product A is 35.08 pieces.

5. SUGGESTIONS ON PURCHASING STRATEGY OPTIMISATION UNDER UNCERTAINTIES

To reduce the loss of potential sales opportunities when demand exceeds supply, and lower the waste caused by unsellable products when supply exceeds demand, the purchase quantity of cross-border e-commerce products can be predicted by using the newsvendor model based on previous sales data, provided that the demand fluctuation is small. This section analyses the purchasing strategy using the newsvendor model by considering discrete and continuous stochastic demand variables based on the market sales of cross-border e-commerce product A, to obtain the optimal purchase quantity for profit maximisation.

First, for cross-border e-commerce products that are easily damaged in transportation, commodity inspection or customs clearance processes, a purchasing pattern featuring small batches and high frequency should be adopted. In addition, time, environment and other factors should be considered, so as to reduce inventory and management costs of cross-border e-commerce enterprises.

Second, in the process of transportation, circulation, commodity inspection and customs clearance, it is necessary to implement strict management procedures for cross-border e-commerce products according to their characteristics. Furthermore, logistics-related measures such as surface cleaning, shockproof packaging, prevention of trampling and stacking, and secondary cleaning should be adopted to ensure product quality and minimise losses caused by product mishandling and other related problems.

Third, it is necessary to synchronise inventory information in real-time to minimise losses caused by stock shortages. In addition, enterprises can reversely affect the market demand through their sales plans. For goods to

be ordered up, an enterprise may reduce the number of sales plans to leave room for the inventory control system to respond, while for unmarketable goods which requires promotion, the enterprise may increase the planned sales volume to reduce inventory pressure.

6. CONCLUSIONS

This study focused on purchasing strategy optimisation for cross-border e-commerce products under uncertainties. Limited by assumptions in this paper, the following problems needs to be further studied:

(1) This paper only examined the optimal purchasing decision-making technique for cross-border e-commerce enterprises in the case of a single supplier. However, in real life, in order to minimise procurement risks, enterprises usually purchase from multiple suppliers. Therefore, in future works, the model can be further expanded to cover multiple suppliers.

(2) In the research process, other factors that may affect the cross-border e-commerce purchasing strategies were simplified, such as the promotion of cross-border e-commerce platforms, consumers' preferences and so on. Therefore, this paper can be improved upon by considering influences from multiple factors in regards to effective and practical purchasing strategies.

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