Portfolio Purchasing Decision for Mobile Power Equipment of B2C E-Commerce Export Retailer Based on CVaR

Wan Yanchun*, Chen Qiucen

School of Economics and Commerce, South China University of Technology, Guangzhou 510006, China

* Email: tcycwan@scut.edu.cn

Abstract. Purchasing is an important part of export e-commerce of B2C, which plays an important role on risk and cost control in supply management. From the perspective of risk control, the paper construct a CVaR model for portfolio purchase. We select a heavy sales mobile power equipment from a typical B2C e-commerce export retailer as study sample. This study optimizes the purchasing strategy of this type of mobile power equipment. The research has some reference for similar enterprises in purchasing portfolio decision.

1. Introduction

The cross-border e-commerce is an international trade activities that different transaction main body completes transaction through cross-border e-commerce platform deal, payment and delivery of goods through cross-border logistics. With low threshold, little links, short cycle and low cost advantage, cross-border e-commerce is showing unprecedented explosive growth in recent 10 years. In traditional international trade, most of the profits go to import/export agents, wholesalers and retailers rather than manufacturers, whose returns is quite small. With the development of e-commerce technology, more and more Chinese mainland's manufacturers have begun to use of online platforms to sell goods directly to overseas consumers (B2C).

Research institute of Ali shows that B2C cross-border exports of China is about 35 billion in 2015, the annual growth rate is 50%. In 2020, export trading of Chinese cross-border e-commerce supplier will reach 12 trillion yuan, accounting for about 37.6% of Chinese total international trade volume. Chinese B2C e-commerce export supplier trading volume will exceed 3.6 trillion yuan, an average annual growth about 37%, and the share of B2C will exceed 30%.According to statistics, procurement cost of Chinese B2C e-commerce export retailers accounts for 30%~60% of turnover, and logistics costs accounts for 15~30% turnover. As the sales of products are influenced by many factors, the purchase and supply chain risk becomes an important problem for all B2C e-commerce export retailers.

CVaR as a risk measurement tool, was developed on the basis of VaR. It was originally applied to the economic problem. Rockafellar & Uryasev(2002), Alexander & Baptista(2004) and Wang, Jia & Liu(2016) build investment model based on CVaR. Larson(2001) puts forward that risk management is the key problem in supply chain management. In the past, the supply chain risk decision-making based on CVaR is mostly used in manufacturing enterprises. Jiang et al., (2007) studies the risks of decentralized multi product from multiple suppliers' demand uncertainty based on CVaR. Yang et al.,(2009) study the coordination of supply chains with a risk-neutral supplier and risk-averse retailer based on CVaR. Liu et al., (2010) studied the pricing and ordering strategy of the two echelon supply chain under the profit -CVaR criterion, reflecting the desire to pursue the highest profit, and taking into

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

account the control of potential risks. Mahaparta et al.,(2017) develop a purchasing decision model combining contracts and open market sourcing alternatives. The model determine the optimal pattern of procurement from the two arrangement for specified price, risk aversion and contract duration parameters. A few scholars begin to pay attention to the online retailer's purchasing problem.For example, Shu et al.,(2017) believe demand is dynamic and highly uncertain by large-scale promotion online. The research proposes a pulsed demand model and establishes a procurement decision model within the expected utility framework from the perspective of risk-averse retailer.

This study attempts to introduce the CVaR risk decision model into the purchasing decision of B2C e-commerce export retailer, which has certain innovation and practical significance.Purchasing characteristics of B2C e-commerce export retailer is of long purchasing cycle and high price fluctuation. CVaR risk measure method can well meet the actual purchase of B2C e-commerce export retailer. This study uses the CVaR risk measurement method to optimize B2C e-commerce export retailer purchasing strategy.

2. Mathematical model

2.1.CVaR Measure Index

CVaR(Conditional Value-at-Risk) is the expected loss of an enterprise's decision over a given period of time over a given VaR value at a given probability level. VaR(Value-at-Risk) means the maximum possible loss of an enterprise's decision at a given probability level over a specific period of time. VaR has no measure of the value of the loss after VaR also. So, VaR has some limites in the use of purchasing decisions. The deduction of the CVaR formula is as following.

Let $\boldsymbol{f(x,\xi)}$ as a loss function of decision vector $\mathbf{x} \in \mathbf{X} \subseteq \boldsymbol{R^n}$， $\boldsymbol{x}$ is the decision vector of the portfolio purchasing decision，$\boldsymbol{\xi}$ stands for potential impact factors on loss, such as market price, stock, $\boldsymbol{\xi} \subseteq \boldsymbol{R^m}$. The probability density of $\boldsymbol{\xi}$ is assumed to be P($\boldsymbol{\xi}$).To every portfolio purchasing decision $\boldsymbol{x} \in \mathbf{X} \subseteq \boldsymbol{R^m}$， The probability of loss no more than a certain probability is:

$$\Psi(x,a) = \int_{f(x,\xi)\le a} p(\xi)d\xi \tag{1}$$

The value of VaR under given confidence levels is:

$$a\beta(x) = \min\{a \in R, f(x,\xi,a\} \ge \beta \tag{2}$$

and：

$$\mathrm{CVaR}\beta(x) = \mathrm{E}[f(X,R,a) \mid > VaR\beta(x)] \tag{3}$$

so value of CVaR is：

$$\phi_\beta = min\{x \in \mathrm{R}{:}\Psi(x,a) \ge \beta\} \tag{4}$$

Define:

$$\mathrm{F}_\beta(x,a) = a + \frac{1}{1-\beta}\int [f(x,a)-a]^+ P(\xi)d\xi \tag{5}$$

$$[f(x,a)-a]^+ = \begin{cases} f(x,a)-a & f(x,a) > a \\ 0 & f(x,a) \le a \end{cases}$$

In the formula above, a stands for the loss value, and β is the confidence level.

2. 2. Electronic commerce purchasing portfolio optimization model

Differ from domestic electronic supplier, the export of cross-border electronic supplier faces larger market fluctuations, more changes in platform policies, logistics, transportation and many other uncertainties in purchasing process. In order to ensure the sale of goods in different electronic business platform, export cross-border electricity supplier must pay more attention to the procurement strategy. Chinese export e-commerce company usually uses different purchasing batch as major considerations. Different purchasing batch plays important effects on logistics system, stock management and profitability. Cross-border export electricity suppliers of Chinese mainland are still in the development market stage, which are willing to adopt more secure procurement strategy. The research establishes a portfolio purchasing decision-making model on export e-commerce enterprise based on CVaR method.

Suppose the export cross-border electronic supplier has M kinds of procurement strategies. The weighted values of each purchasing policy are represented by $\boldsymbol{x_i}$.So, the purchasing strategy portfolio can be represented as:

$$x^T = (x_1, x_2, \dots x_M) \tag{6}$$

Suppose ξ_i represents purchasing cost corresponding to the purchasing strategy. The total cost of the purchasing strategy portfolio can be represented as:

$$\xi^T = (\xi_1, \xi_2, \dots, \xi_M) \tag{7}$$

The cost function of the purchasing strategy portfolio on export e-commerce enterprise can be represented as:

$$f(x, \xi) = x_1\xi_1 + x_2\xi_2 + \cdots x_M\xi_M = x^T\xi \tag{8}$$

$$\mathrm{E}\, f(x, \xi) = x^T\mu \tag{9}$$

According to (8) and (5), we can derive following function:

$$\mathrm{F}_\beta(x, a) = a + \frac{1}{1-\beta}\int_{\xi \in R^m}[f(x, a) - a]^+ P(\xi)d\xi \tag{10}$$

We use discrete methods to instead of complex integral, suppose the sample number of purchase costs is K.

$$\mathrm{F}_\beta(x, a) = a + \frac{1}{K(1-\beta)}\sum_{k=1}^{K}[x^T\xi_K - a]^+ \tag{11}$$

It is difficult to solve a piecewise function, in the study, we make:

$$S_k = [x^T\xi_K - a]^+ \tag{12}$$

So:

$$\mathrm{F}_\beta(x, a) = a + \frac{1}{K(1-\beta)}\sum_{k=1}^{K} S_k \tag{13}$$

$$\text{s.t.} \quad S_k \geq f(x, \xi_k) - a,\ S_k \geq 0, k = 1,2, \cdots, \mathrm{K}$$

According to above deduction, we can gain the optimal portfolio purchasing model in minimize CVaR as following:

$$\min_{(x,a)\in X} F_\beta\,(x, a, s) = min\left[a + \frac{1}{K(1-\beta)}\sum_{k=1}^{K} s_k\right] \tag{14}$$

$$s.t.\ \sum_{i=1}^{M} x_i = 1 \quad x_i \geq 0$$

$$x^T\mu \leq P$$

$$s_k \geq x^T y_k - a \quad s_k \geq 0$$

P is upper cost limit of purchase, in export of cross-border electronic supplier, the value is less than the difference between the selling price and the logistics cost.

3. Numerical examples of purchasing portfolio strategy

3. 1. Sample enterprise and data acquisition

The sample B2C e-commerce export retailer is abbreviated as DML, which was founded in 2013. DML sells more than 800 items on Amazon platform, which is one of the most popular platforms for customers in Europe and America. DML managers believe that Amazon is also the most powerful platform of cross-border electricity supplier, which provides good service, encouraging them to create their own brand. In the following several years, DML will still not consider selling products on other platforms.

The main products sold by the sample company of B2C e-commerce export retailer are peripheral products of 3C, namely computer, communication and consumer electronics. DML also sells security products, health products, beauty products and other products. Figure 1 shows: peripheral products of 3C account for 54.35% of the turnover ratio of DML, which includes 31.02% turnover from mobile power equipment. Mobile charging equipment is the most important category of the sample company. The category includes about 150 items. We select the most sale item 573MPP-0006(short for MPP6) as the object of purchasing portfolio strategy research.

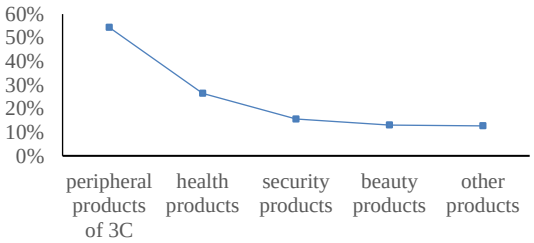


Fig 1. Sales distribution of DML's products

Table 1. Purchasing Price and variance of 573MPP-0006 ($/pcs)

Procurement Strategy	mass procurement	bulk purchasing	batch purchasing
expected value of Purchasing Price	29.64	30.76	32.31
variance	0.537	0.412	0.205

At present, procurement methods of mobile charging equipment MPP6 include mass procurement, bulk purchasing and small batch purchasing. The numbers of mass procurement is not less than 10000 pieces. Small batch purchasing is to buy a month's demand, and the number of bulk purchasing is between mass procurement and small batch purchasing. Mass purchasing can get price discount and reduce purchasing cost. However, due to the large number of goods shipped to the FBA warehouse, DML may face high risk, such as changes in market demand, product aging, inventory backlog and other risks. The cost of small batch procurement is higher than mass procurement, but it can effectively improve inventory turnover. Once out of stock, business operators can meet consumer demand by air transportation, which can effectively reduce business risk.

In the past years, DML purchased MPP6 by using a large number of procurement methods, which makes the turnover rate of DML lower than the level of peers. Once Amazon platform shuts down the item's account temporary by some reasons, meanwhile the mass of goods purchased by the sample company in advance, which will continue to be shipped to the FBA warehouse, DML will face a sharp rise in inventory. Under these circumstances, DML will confront with the difficulty of cash flow, accompanied by great operational risks. DML have encountered temporary closure of the platform for 2 months in 2016, which brought the stock backlog rising sharply. Managers of DML had to temporarily mobilize large amounts of cash to pay suppliers, resulting in cash flow facing the risk of fracture. So, It is necessary to optimize the procurement decision to achieve the goal of reducing risk under a certain confidence level and appropriately increasing procurement costs.

According to the DML's purchasing price of 2016, the price and variance of mass procurement, bulk purchasing and small batch purchasing list in Table 1.

3. 2. Numerical example optimization results analysis

3.2.1. The optimal strategy at a constant confidence

Set 300 samples of future MPP6 mobile power equipment prices, which are generated at random by normal distribution. The model (15) is optimized by using Matlab software. Among them, M=3,$\boldsymbol{x_1}, \boldsymbol{x_2}, \boldsymbol{x_3}$ respectively indicate the weight of mass purchasing, medium batch purchasing and small batch purchasing. Make $\boldsymbol{\beta = 0.95}$ and repeat the above calculations by changing the expected cost of the model in the largest P. We can expect the cost -CVaR curve (Fig.2), also known as the efficient frontier curve.

As we can see from the Fig 2, the effective frontier curve is a downward sloping curve at a given confidence level (0.95). With the increase of purchasing cost under the combination purchasing strategy, the CVaR value of MPP6 procurement is decreasing continuously, and when the level reaches a certain level, the CVaR value is no longer changing, which means that under this confidence level, the procurement portfolio strategy has reached its optimum. When the electronic supplier enterprises are risk averse, they will increase the weight of small quantities of procurement, at the same time, MPP6 procurement cost continue to rise, the risk of enterprises is declining. But to a certain extent, CVaR no longer drops, which means the increase of purchasing cost will not bring lower risk. When the CVaR value is no longer down, the lowest cost strategy is the best combination strategy of cross-border electricity supplier purchasing MPP6.

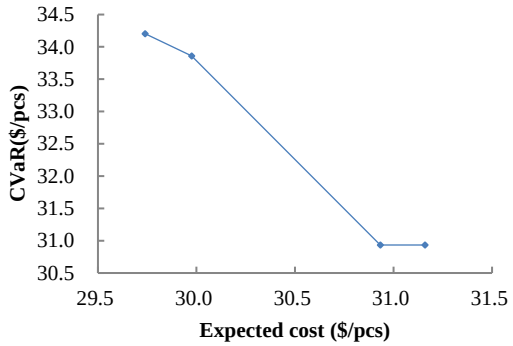


Fig 2. The efficient Frontier curve

Table 2. Results in different confidence under optimal decision

β	x_1	x_2	x_3	CVaR	Purchasing cost
0.75	0.332	0.447	0.221	31.46	30.73
0.80	0.321	0.445	0.234	31.51	30.76
0.85	0.310	0.426	0.264	31.54	30.82
0.90	0.304	0.420	0.276	31.64	30.85
0.95	0.291	0.387	0.322	31.57	30.93

At a confidence level of 0.95, with the continuous increase of CVaR, the proportion of mass procurement is rising in procurement of MPP6, meanwhile the bulk purchasing increases first and then decreases, and the proportion of small batch purchases gradually decreases. In actual operation, when the B2C e-commerce export retailer has enough fund, the retailer will increase the proportion of bulk procurement. Then, the purchasing cost will decrease, but the enterprises will face more risks. Therefore, any B2C e-commerce export retailer need to balance the cost and risk.

3.2.2. Procurement optimization strategy under different confidence levels

Table 2 shows that when DML uses different confidence levels to make a portfolio purchasing decision for MPP6, the enterprise can obtain the procurement strategy with the lowest CVaR value. Under different confidence levels, the weight of DML using mass procurement, bulk purchasing and small batch of MPP6 is different. With the increase of confidence level, mass procurement and bulk purchase ratio decreased, small batch purchase ratio increased.

4. Conclusions and Prospect

This study takes DML as the sample of B2C e-commerce export retailer, and selects its representative SKU MPP6 as the sample data in purchasing decision-making. The MPP6 procurement practices are simplified into three purchasing strategies, mass procurement, bulk purchasing and small batch purchasing.

According the study, at a certain confidence level, CVaR value decreases gradually with the increase of the purchasing cost. When CVaR reaches a certain level, the value does not change, which means the purchasing portfolio strategy is the most optimal strategy. With the improvement of confidence level, to achieve the optimal purchasing strategy, the procurement cost of B2C e-commerce export retailer is increasing gradually with the increase of confidence level, mass procurement and bulk purchase ratio decreased, small batch purchase ratio increased.

In future studies, some problems need attention: This study did not consider the capital constraint in purchasing decision model. In practice, capital is an important factor affecting the purchase decision. In future research, capital constrains should be added to purchasing decision-making model.In numerical example optimization of this study, the purchase cost of goods only consider the purchase cost of MPP6. In practice, different purchasing scale of the procurement may be accompanied by different modes of transport. The result of the decision may be different.

Acknowledgments

This study is supported by Natural Science Foundation of Guangdong Province Doctor Startup Project (No. 2015A030310401), Research on multi sourcing risk evaluation and optimization decision based on CVaR from the perspective of social capital.

References

[1] Alexander G, Baptista A M 2004 A comparison of VaR and CVaR constraints on portfolio selection with the mean-variance model, *America, Management Science* 50 pp 1261-1273
[2] Jiang Min, Meng Zhiqing, Zhou Gengui 2007 Conditional risk decision model of ordering portfolio muliproduct and inventory problem in supply chain. *China, Systems Engineering-Theory & Practice*, **27** (12) pp 29-35
[3] Larson P. D. 2001 Designing and managing the supply chain: concepts, strategies, and case studies. *Journal of Business Logistics,* **22**(1) pp 259-261
[4] Liu Jian, Luo Chunlin 2010 Pricing and ordering strategies in a two-echelon supply chain under criterion of profit-CVaR. *China, Control and Decision*, **25** (1) pp 130-136
[5] Mahaparta S, Levental S, & Narasimhan B 2017 Market price uncertainty, risk aversion and procurement: combining contracts and open market sourcing alternatives. *America, International Journal of Production Economics*, **185** pp 34-51
[6] Rockafellar T & Uryasev S 2000 Optimization of conditional Value-at-risk. *America, Journal of Risk,* **2**(3) pp 21-41
[7] Shu L, et al, 2017 Risk-averse procurement strategy under large-scale promotion online considerding strategic customer. *China, Computers & Industrial Engineering*, **26**(1) pp 135-160, Http://dx.doi.org/10.1016/j.cie.2016.12.043
[8] Wang Liang, Jia Yujie, Liu Xiao 2016 ETF optimal asset allocation and empirical research based on dynamic conditional risk constraint under time-varying loss-aversion. *China, Chinese Journal of Management Science*, **24**(12) pp 54-62
[9] Yang Lei et al, 2009 Supply chain coordination with CVaR criterion. *Singapore, Asia-Pacific Journal of Operational Research*, **26**(1) pp 135-160