

The newsvendor problem with reference dependence, disappointment aversion and elation seeking



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ABSTRACT

We study the newsvendor problem considering newsvendor's three psychological behaviors: reference dependence, disappointment aversion and elation seeking, and investigate the impact of the three psychological behaviors on newsvendor's optimal policy. We first analyze the characteristics and relation of three behaviors, and give the newsvendor's utility function which is consisted of the economic payoff (i.e., profit) and psychological satisfaction (i.e., behavioral utility). Then, we introduce the three behaviors into the newsvendor model, and re-construct the newsvendor model considering the effects of the three behaviors. Furthermore, we prove that the uniquely optimal solution exists and give the optimal solutions for several situations of the behavioral parameters' values. Finally, we provide the numerical study to show how the three psychological behaviors affect the optimal solution. The research result shows that the order quantity increases with elation seeking parameter, but decreases with reference dependence parameter and disappointment aversion parameter. It also shows that the newsvendor who exhibits reference dependence, disappointment aversion and elation seeking should consider the respective and interactive effects of three psychological behaviors in decision-making.

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1. Introduction

The newsvendor problem refers to the order quantity decision-making problem, in which the newsvendor determines the order quantity to maximize the expected profit in a single-period probabilistic demand framework, it is a significant and fundamental problem in operations management and has attracted extensive concern from both the academia and the practice [14,16,17,22,24,27,29,35]. In recent years, many theoretical research results have been obtained on newsvendor problem, but most of them are based on the perfectly rationality assumption that the newsvendor is the perfect optimizer who always takes actions to maximize the expected payoff and obtains the perfect information of the market [6,7,10]. In reality, it seems not practical since the newsvendor usually exhibits the bounded rationality, i.e., exhibits some psychological behaviors such as reference dependence, loss aversion, disappointment aversion and elation seeking, and the newsvendor usually takes actions to maximize his/her expected utility which is consisted of the economic payoff and the psychological satisfaction [2,6,16,20,31]. Theoretically, some scholars find

that the optimal policy of the newsvendor is usually affected not only by the objective factors such as uncertain demand and exogenous price but also by the subjective factors such as the newsvendor's psychological behaviors induced by the risk.

Many scholars have been attracted by the study on psychological behaviors effects in the newsvendor setting, they attempt to discover some psychological behaviors exhibited by the newsvendor in decision-making [2,20,31]. In addition, some scholars study why the newsvendor exhibits the behaviors and analyze the impacts of the behaviors on optimal policy by experimental studies [18,26,28,33]. Currently, the psychological behaviors involved in above studies mainly contain bounded rationality [1,5,6,28,32], decision bias [7], reference dependence [15,19,36,37], loss aversion [13,16,21,23,30,31,34], overconfidence [25] and fairness concern [8,33]. However, in reality, the newsvendor may not only exhibit these behaviors, but also may exhibit disappointment aversion and elation seeking behavior.

Disappointment or elation is a subjective response related to the anticipated rewards [2,26]. The disappointment is caused by the perceived loss between the real profit and the expectation, the elation is caused by the perceived gain between them. The newsvendor is usually averse to disappointment and seeking to elation, [2,18,20]. Since disappointment aversion and elation seeking are obviously different from other behaviors, the existing

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research results on other psychological behaviors are not suitable to solve the newsvendor problem when the newsvendor exhibits three psychological behaviors: reference dependence, disappointment aversion and elation seeking. Therefore, it is necessary to study the newsvendor problem with the three psychological behaviors.

In this paper, we extend the classical newsvendor model from the perspective of reference dependence, disappointment aversion and elation seeking. First, we describe the newsvendor's utility framework proposed by Bell [2] and demonstrate the newsvendor's economic payoff and the psychological satisfaction. Then, we analyze the reference dependence, disappointment aversion and elation seeking, and use a linear behavioral function to depict the utility of disappointment aversion and elation seeking. Further, the newsvendor's utility model is presented by integrating behavioral function and profit function. In addition, the optimal policy can be obtained by solving the model for the newsvendor who exhibits reference dependence, disappointment aversion and elation seeking.

The contribution of this study mainly contains three aspects. First, we consider and depict three psychological behaviors exhibited by the newsvendor in newsvendor setting, i.e., reference dependence, disappointment aversion and elation seeking. Secondly, given that disappointment aversion and elation seeking are psychological behaviors based on reference dependence, we construct the newsvendor model considering comprehensively the respective and interactive impacts of three psychological behaviors, and the optimal order quantity can be obtained by solving the model. Thirdly, we give the analysis of impacts of the newsvendor's behaviors on the optimal order quantity through numerical study.

The rest of this paper is organized as follows. Section 2 formulates the newsvendor problem with reference dependence, disappointment aversion and elation seeking. Section 3 solves the model and provides the analysis of the impacts of the reference dependence, disappointment aversion and elation seeking on the optimal order quantity. Section 4 gives the numerical study. In Section 5, the managerial insights of this study are given. Section 6 concludes and suggests possible extensions of this paper.

2. Model

Extensive experiments on the behavioral operations management are conducted to explore the relation between the decision-maker's psychological behaviors and his/her decisions, they suggest that decision-maker's psychological behaviors such as disappointment aversion and elation seeking can affect his/her decision under uncertainty [2,20,18]. To capture and depict the impacts, Bell [2] proposed a simple model, and maintains that the decision-maker's utility contains the utility derived from the real profit and the one derived from their psychological behaviors. The model is shown as

$$\text{Utility} = \text{economic payoff} + \text{psychological satisfaction}. \quad (1)$$

In the following, the specific analysis process on economic payoff and psychological satisfaction is given.

2.1. Profit: economic payoff

We consider a newsvendor problem, the newsvendor has to determine the order quantity to maximize his/her utility before the selling season, and sells the products at price p with unit purchasing cost c . If order quantity Q is lower than the realized market demand, the shortage cost s incurs; if greater than realized demand, the unsold stock cost, i.e., salvage value v , incurs. Usually, $p > c > v$. Consider that the demand D is a continuous stochastic variable, $D \in [A, B]$, the probability density function and the

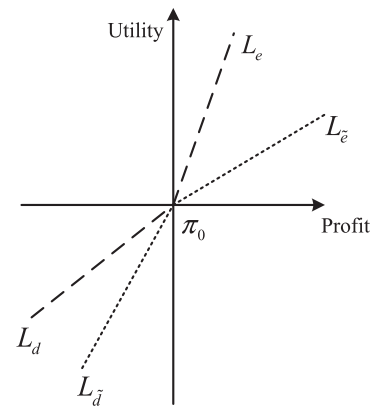


Fig. 1. The utility function of disappointment aversion and elation seeking when $\pi^{\min} < \pi_0 < \pi^{\max}$.

cumulative distribution function are $f(D)$ and $F(D)$, the mean of D is μ .

For the demand uncertainty, we consider the profit function is

$$\pi = \begin{cases} \pi_{D < Q} \\ \pi_{D \geq Q} \end{cases}. \quad (2)$$

where $\pi_{D < Q} = (p - c)D - (c - v)(Q - D)$ and $\pi_{D \geq Q} = (p - c)Q - s(D - Q)$, then Eq. (2) can be rewritten as

$$\pi = \begin{cases} (p - c)D - (c - v)(Q - D), & \text{if } D < Q \\ (p - c)Q - s(D - Q), & \text{if } D \geq Q \end{cases}. \quad (3)$$

2.2. Utility function of psychological behaviors: psychological satisfaction

Disappointment aversion and elation seeking are first proposed by Bell [2] in the framework of disappointment theory, and further analyzed by Gul [12], Delqu   and Cillo [9] and Liu and Shum [18]. They are important psychological concepts which receive increasing attention in behavioral operations management in recent years [11,18]. It is necessary to point out that disappointment aversion and elation seeking are directly related to the reference point of the newsvendor. Generally, the reference point is the newsvendor's profit expectation. Given the heterogeneity of the newsvendor, the reference point, denoted as π_0 , may be arbitrary one in the range $[\pi^{\min}, \pi^{\max}]$, where $\pi^{\min}$ and $\pi^{\max}$ denote the theoretical minimum and maximum of the profit, $\pi^{\min} = \min[-(c - v)Q, -sD]$, $\pi^{\max} = (p - c)D$. If the reference point π_0 satisfies $\pi^{\min} < \pi_0 < \pi^{\max}$, then the utility function of disappointment aversion and elation seeking can be described in Fig. 1, where L_e and $L_{\bar{e}}$ imply the lines with different degrees of elation seeking, L_d and $L_{\bar{d}}$ imply the lines with different degrees of disappointment aversion.

Since the newsvendors may be heterogeneous, the degree of the elation seeking may be higher than the one of the disappointment aversion as L_e and L_d shown in Fig. 1, and it may be also lower than the one of the disappointment aversion as $L_{\bar{e}}$ and $L_{\bar{d}}$ shown in Fig. 1. If $\pi_0 = \pi^{\max}$, then the function can be described in Fig. 2. If $\pi_0 = \pi^{\min}$, then the function can be described in Fig. 3. Generally, the profit expectation is usually greater than or equal to 0, but is less than or equal to the theoretical maximum of the profit $\pi^{\max}$. Therefore, in this paper, we consider that $\pi_0 \in [0, \pi^{\max}]$, and let $\pi_0 = \alpha \pi^{\max}$, where α denotes the newsvendor's reference dependence parameter, $\alpha \in [0, 1]$. The greater the parameter α is, the higher the newsvendor's profit expectation is.

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