

# The loss-averse newsvendor problem<sup>☆</sup>

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## Abstract

Newsvendor models are widely used in the literature, and usually based upon the assumption of risk neutrality. This paper uses loss aversion to model manager's decision-making behavior in the single-period newsvendor problem. We find that if shortage cost is not negligible, then a loss-averse newsvendor may order more than a risk-neutral newsvendor. We also find that the loss-averse newsvendor's optimal order quantity may increase in wholesale price and decrease in retail price, which can never occur in the risk-neutral newsvendor model.

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## 1. Introduction

The newsvendor problem is one of the fundamental models in stochastic inventory theory [1]. The newsvendor's objective is to choose an optimal order quantity to balance his cost (or disutility) of ordering too many against his cost (or disutility) of ordering too few. Because of its simple but elegant structure, the newsvendor problem also applies in various settings such as capacity planning, yield management, insurance, and supply chain contracts.

The standard newsvendor model is based upon risk neutrality so that managers will select an order quantity to maximize expected profit. However, in practice,

there are many counter examples indicating that managers' order quantity decisions are not always consistent with maximizing expected profit. For example, Kahn [2] finds that Chrysler held larger inventory stocks than competitors such as GM and Ford before early 1980, which seemed to imply the *stockout-avoidance* behavior (see also [3,4]). We refer to the deviation of the newsvendor's optimal order quantity from the profit maximization order quantity as *decision bias* in the newsvendor problem.

One major reason why decision bias may exist in the newsvendor problem is that a manager may have preferences other than risk neutrality [5]. In this paper, we attempt to use an alternative choice model—loss aversion—to describe the newsvendor decision bias. Loss aversion states that people are more averse to losses than they are attracted to same-sized gains. There are two main reasons why we use loss aversion to describe the decision bias in the newsvendor problem. First, loss aversion is both intuitively appealing and

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well supported in finance, economics, marketing, and organizational behavior (see [6,7] for more detailed reviews). This paper is especially motivated by two empirical studies of managerial decision-making under uncertainty. The first study by MacCrimmon and Wehrung [8] is based on questionnaire responses from 509 high-level executives in American and Canadian firms, and interviews with 128 of those executives in 1973–1974. The second study by Shapira [9] is based on interviews with 50 American and Israeli executives in 1984–1985. Managers' decision-making behavior in both studies is consistent with loss aversion. Second, in contrast with the widely applications and empirical supports of loss aversion in other fields, unfortunately, the development of loss aversion to describe manager's newsvendor decision bias is still in its early stages. As far as we know, Schweitzer and Cachon [5] is the only paper studying a loss-averse newsvendor problem. They show that a loss-averse newsvendor (with no shortage cost) will order strictly less than a risk-neutral newsvendor. However, the newsvendor's decision-making behavior is unclear from their model if (1) shortage cost is considered and (2) some price or cost is changing. To fill in this research gap, we extend their model by considering the shortage cost and summarizing comparative statics of price and cost changes.

The purpose of our research is to build a theoretical model that characterizes the outcomes of the decision bias of a loss-averse newsvendor, i.e., to show when, how, and why loss aversion causes the decision bias in the newsvendor problem. We use a simple "kinked" piecewise-linear loss-aversion utility function to study the single-period newsvendor model. We find: (1) a loss-averse newsvendor will order less than the risk-neutral newsvendor if he faces low shortage cost and the more loss-averse, the less his optimal order quantity; (2) a newsvendor will order more than the risk-neutral newsvendor if he faces high shortage cost and the more loss-averse, the more his optimal order quantity. We also discuss some comparative statics of price and cost changes. We find that the loss-averse newsvendor's optimal order quantity may increase in wholesale price and decrease in retail price, which can never occur in the risk-neutral newsvendor model. Our research contributes to the newsvendor literature in two main aspects. First, we quantify the newsvendor decision bias and show how the newsvendor loss aversion decision bias interacts with the business conditions, e.g., retail price, wholesale price, shortage cost, and degree of loss aversion, *when shortage cost exists*. Second, since a loss-averse newsvendor orders from his supplier a different quantity from the profit-maximizing quantity, the

total supply chain performance is suboptimal. Hence, our research findings also lend insights into how loss aversion contributes to supply chain inefficiency and may lead to new policies for mitigating these effects.

This paper is organized as follows. In Section 2, we briefly review the literature related to our research. In Section 3, we analyze our single-period loss-averse newsvendor model. In Section 4, we analyze the effects of changing parameter values. Finally, in Section 5, we draw our conclusions and identify opportunities for future research.

## 2. Related newsvendor literature

The traditional newsvendor model is based upon risk neutrality; managers place orders to maximize expected profits (e.g., [1,10,11]). Recently, a number of attempts have been made to extend our understanding of the newsvendor model. Lippman and McCardle [12] study the competitive newsvendor problem. Petruzzi and Dada [13] provide a survey of the newsvendor problem where both price and quantity are set simultaneously. Casimir [14,15] study the value of information in the single and multi-item newsvendor problems. Carr and Lovejoy [16] consider a newsvendor who chooses which customers to serve given his fixed capacity. Dana and Petruzzi [17] study a newsvendor model in which consumers choose between attempting to purchase the newsvendor's product and an exogenous alternative. Van Mieghem and Rudi [18] introduce newsvendor networks, which generalize the classic newsvendor model and allows for multiple products and multiple processing and storage points. Cachon and Kok [19] study a newsvendor model with clearance pricing for the leftover inventory at the end of the selling season, which contrasts with the traditional assumption of a constant salvage value assigned to each unit of unsold inventory. Mostard et al. [20] and Mostard and Teunter [21] study the newsvendor problem where undamaged returned products from customers during the selling season are still resalable before the season ends.

In addition to risk neutrality, some researchers have attempted to use risk aversion within Expected Utility Theory (EUT) to describe the decision-making behavior in the newsvendor problem. Eeckhoudt et al. [22] study a risk-averse newsvendor who is allowed to obtain additional orders if demand is higher than his initial order. They find that a risk-averse newsvendor will order strictly less than a risk-neutral newsvendor. Agrawal and Seshadri [23] investigate a risk-averse and price-setting newsvendor problem. They find that a risk-averse newsvendor will charge a higher price and order less

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