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BICRITERIA OPTIMIZATION IN THE RISK-ADJUSTED NEWSVENDOR PROBLEM

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Abstract

In this paper, we study the newsvendor problem with various degrees of risk tolerance. We consider bicriteria optimization where the first objective is the classical maximization of the expected profit and the second one is the satisficing-level objective. The results depend on the risk coefficient and are different for a risk-neutral, a risk-averse, and a risk-seeking retailer. We find the compromise solution of the bicriteria newsvendor problem numerically, since the two objectives are mutually conflicting. The formulas obtained are illustrated with exponentially distributed demand.

Keywords: stochastic demand, newsvendor problem, bicriteria optimization, risk.

1 Introduction

The single-period newsvendor problem is one of the most fundamental inventory models (cf. Silver et al., 1998). In the classical version of this problem the objective is to maximize the expected profit, but many other objectives can be used. A survey of this topic has been performed recently by Qin et al. (2011). Sometimes, it is more relevant to consider the retailer's risk tolerance. In the newsvendor model, various degrees of risk can be assumed. The most popular measures assuming risk aversion are Value-at-Risk (VaR) and Conditional Value-at-Risk (CVaR). Lately, Teunter et al. (2013a) have studied how the capacity for uncertainty influences inventory decisions of a risk-averse newsvendor using the VaR and CVaR criteria. These criteria have also been studied by Teunter et al.

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(2013b), but with uncertainty in the shortage cost. Moreover, in Teunter et al. (2014), under the CVaR criterion, the authors obtain the optimal quantity and pricing decisions under both quantity and pricing competition. The most recent papers in this field are, among others, Özler (2009), Wang and Webster (2009), Xinshenga et al. (2015), Rubio-Herrero et al. (2015), Dia and Mengb (2015), Ray and Jenamani (2016) and Ye and Sun (2016).

The degree of risk tolerance is studied in Arcelus et al. (2012b) and Raza et al. (2017), too. In these papers, the authors consider the newsvendor model with random and price-dependent demand. Among other objectives, they use the risk coefficient into the satisficing-level objective. In general, the satisficing-level objective is defined as the maximization of the probability of the event that the profit is greater than or equal to the prespecified target profit. The satisficing-level objective in the newsvendor problem is treated, for instance, in Kabak and Shiff (1978), Lau (1980), Li et al. (1991), Yang (2011) or Pinto (2016). The satisficing-level objective with a moving target and price independent demand is explored in Parlar and Weng (2003), Arcelus et al. (2012a) and Bieniek (2016), but for a risk-neutral retailer. The moving target considered in these papers is the expected profit.

Here we continue the study of a similar problem, but with a risk-adjusted retailer. It should be noted that the risk-adjusted expected profit is defined in Arcelus et al. (2012b). Moreover, in this paper, the probability of the event that the classical profit is greater than or equal to the risk-adjusted expected profit is maximized for uniformly distributed demand. We analyse a more relevant and more generalized objective, where the profit is replaced by the risk-adjusted profit (a notion introduced in our paper). This is a more appropriate approach to the matter since we study the preferences of the retailer of each kind. Additionally, we solve the satisficing-level risk-adjusted newsvendor problem for general distribution. As a result, we obtain approximate solutions which are strictly dependent on the risk coefficient. We also apply the exponential distribution, which is widely used in practice, to the results obtained. Since the exponential distribution is mathematically tractable, we are able to obtain exact solutions to the problem. It should be emphasized here that the use of the uniform distribution in Arcelus et al. (2012b) also gives exact results, but in real life there are no products whose demand can be modelled by this distribution. Moreover, in our opinion, in the paper cited the solution is not complete because some special cases of the problem should be added and the solution should depend on the risk coefficient. This gap can be complemented by our paper.

Furthermore, in our study we combine the satisficing-level objective with the classical expected profit objective into the bicriteria index. Here the classical objective is to maximize the risk-adjusted expected profit and the satisficing-level objec-

tive is to maximize the probability that the risk-adjusted profit is greater than or equal to the risk-adjusted expected profit. Since these two objectives are mutually conflicting, we find the compromise solution which can be done numerically.

The rest of the paper is organized as follows. Section 2 is devoted to the general bicriteria risk-adjusted newsvendor problem and provides the basic notation and definitions. The notion of a bicriteria index is also recalled. The risk coefficient is recalled and the notion of the risk-adjusted profit is introduced. Approximate solutions of the satisficing-level model and the bicriteria model are presented for the general distribution. In Section 3, the exponential distribution is applied to the results obtained, which allow us to give exact solutions. Next, we illustrate the formulas obtained by a numerical example and draw graphs of auxiliary functions. Finally, we perform sensitivity analysis of the changes of the risk coefficient.

2 The bicriteria newsvendor problem with the risk-adjusted profit – general case

In this section, we recall the definitions of the profit function and the risk-adjusted expected profit, and introduce the definition of the risk-adjusted profit. Using these quantities, we solve the newsvendor problem with a classical risk-adjusted expected profit objective and with a risk-adjusted satisficing-level objective. Finally, we investigate the bicriteria problem with both these objectives.

In the classical newsvendor problem, we examine a retailer who wants to acquire Q units of a given product subject to random demand. We use the following notation. Let:

- $p > 0$ be the selling price for unit (unit revenue);
- $c > 0$ be the purchasing cost per unit;
- $s > 0$ be the unit shortage cost;
- v be the unit salvage value (unit price of disposing any excess inventory);
- $f(\cdot)$ and $F(\cdot)$ be the probability density function and the cumulative distribution function of the demand with mean μ ;
- $\lambda \geq 0$ be the risk coefficient.

The standard assumption is $v < c < p$. The risk coefficient expresses the risk tolerance of the retailer. There are four risk categories. Namely, for $\lambda = 0$ we have a riskless retailer and for $\lambda = 1$, a risk-neutral retailer. For $0 < \lambda < 1$ we are dealing with a risk-seeker and for $\lambda > 1$, with a risk-averse retailer (cf. Arcelus et al., 2012b).

We define the risk-adjusted profit by the formula:

$$\pi_{\lambda}(Q, x) = \begin{cases} (p - c)x - \lambda(c - v)(Q - x), & \text{if } x \leq Q \\ (p - c)x - \lambda(p + s - c)(x - Q), & \text{if } x > Q, \end{cases}$$

where Q is the order quantity and x is the realized demand. Then the risk-adjusted expected profit E_{λ} is equal to:

$$E_\lambda(Q) = (p - c)\mu - \lambda \left[(c - v)(Q - \mu) + (p + s - v) \int_Q^\infty (x - Q)f(x)dx \right]. \quad (1)$$

Arcelus et al. (2012b) justify using the risk coefficient as follows. They state that the first term in the formula for the risk-adjusted expected profit, without the risk coefficient, stands for certain gains. The second term, with the risk coefficient, indicates uncertain losses and includes the variability of the random demand. From this definition, we can further see that the higher the degree of risk-aversion, the higher the value of the risk coefficient.

Now, if the objective is to maximize the risk-adjusted expected profit, then this model gives the same optimal order quantity as the model for a risk-neutral retailer and does not depend on λ . Because of that the order quantity maximizing the risk-adjusted expected profit Q_E^* can be obtained from:

$$F(Q_E^*) = (p + s - c)/(p + s - v).$$

But, in the satisficing-level model, where the objective is to maximize the survival probability, the results depend on the risk coefficient. Here the so-called survival probability $H_\lambda(Q)$ is the probability of the event that the risk-adjusted profit is greater than or equal to the risk-adjusted expected profit, namely:

$$H_\lambda(Q) = P(\pi_\lambda(Q) \geq E_\lambda(Q)).$$

Let Q_H^* be the optimal order quantity which maximizes $H_\lambda(Q)$. The following theorem is crucial for the subsequent analysis because it gives the possible expressions for the survival probability.

Theorem 1

1. If $[(p - c)(1 - \lambda) - \lambda s < 0$ and $\lambda < 1]$ or $\lambda > 1$ then the profit function $\pi_\lambda(Q, x)$ is increasing-decreasing as a function of the realized demand, and the survival probability is equal to:

$$H_\lambda(Q) = \int_{D_1(Q)}^{D_2(Q)} f(x)dx.$$

2. If $(p - c)(1 - \lambda) - \lambda s > 0$ and $\lambda < 1$ then the profit function $\pi_\lambda(Q, x)$ is increasing as a function of the realized demand, and the survival probability:

- a) for $E_\lambda(Q) < (p - c)Q$ is given by:

$$H_\lambda(Q) = \int_{D_1(Q)}^\infty f(x)dx,$$

- b) for $E_\lambda(Q) \geq (p - c)Q$ is given by:

$$H_\lambda(Q) = \int_{D_2(Q)}^\infty f(x)dx,$$

where $D_1(Q) = \max \{0, k(Q)\}$ with:

$$k(Q) = \frac{(c - v)Q + E_\lambda(Q)}{p - v}$$

and $D_2(Q) = \max \{0, l(Q)\}$ with:

$$l(Q) = \frac{(p + s - c)Q - E_\lambda(Q)}{s}.$$

Proof

In this theorem, as compared with the earlier results by Parlar and Weng (2003), the new case 2) occurs. This is a consequence of introducing the risk coefficient. Thus, it is enough to prove this case. Note that if $(p - c)(1 - \lambda) - \lambda s > 0$ and $\lambda < 1$ then the slope of the profit function is positive and $E_\lambda(Q)$ can be greater than $(p - c)Q$, which proves the desired result.

In Figure 1 we illustrate this theorem by the graphs of the profit function as a function of the realized demand.

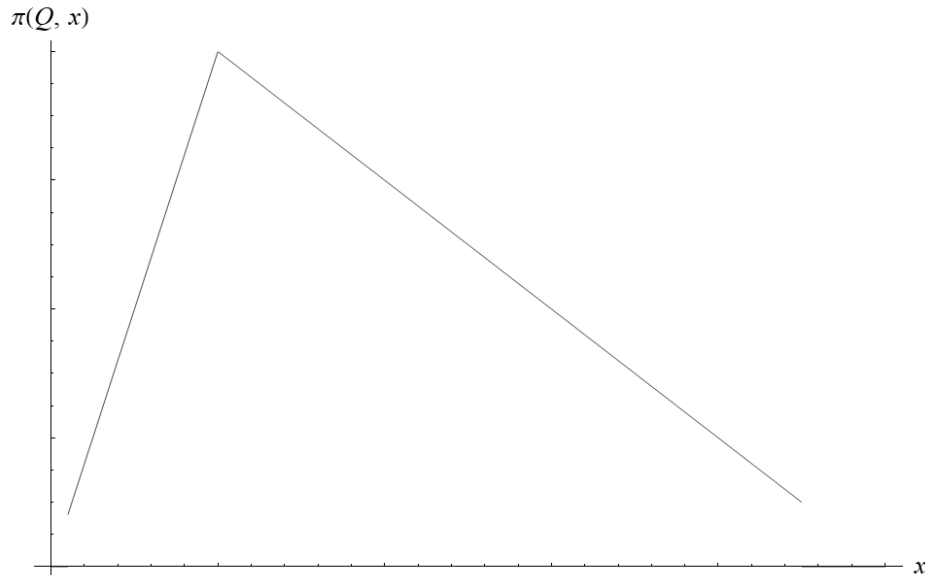


Figure 1. Profit function $\pi_\lambda(Q, x)$ for $[(p - c)(1 - \lambda) - \lambda s < 0$ and $\lambda < 1]$ or $\lambda > 1$

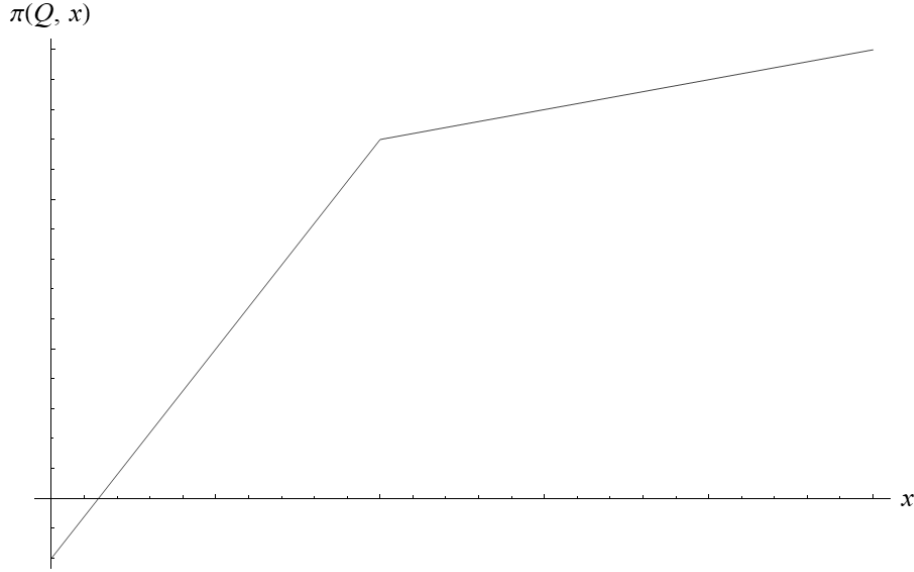


Figure 2. Profit function $\pi_\lambda(Q, x)$ for $(p - c)(1 - \lambda) - \lambda s > 0$ and $\lambda < 1$

Remark 1

Using formula (1), the expressions in the theorem can be written as:

$$k(Q) = \mu - \frac{\lambda(p + s - v) \int_Q^\infty (x - Q)f(x)dx}{p - c + \lambda(c - v)}$$

and:

$$l(Q) = \frac{(p - c + \lambda(c - v))\mu - \lambda(p + s - v)[Q + \int_Q^\infty (x - Q)f(x)dx]}{p - c - \lambda(p + s - c)}.$$

Remark 2

Case b) of Theorem 1 is satisfied for a risk-seeker and for products for which $(p - c)(1 - \lambda)/\lambda > s$. It corresponds to the situation when the shortage cost per item is smaller than the maximal profit per item multiplied by $\frac{1-\lambda}{\lambda}$.

Now, we examine the variability of the survival probability. To this aim it is necessary to analyse the variability of the limit functions. First, we explore the monotonicity and the zeros of these functions. Note that all results involve the risk coefficient.

For the lower limit, we have:

$$k(0) = \frac{(p - c)(1 - \lambda) - \lambda s}{p - c + \lambda(c - v)} \mu.$$

Thus $k(0) > 0$ for $[(p - c)(1 - \lambda) - \lambda s > 0$ and $\lambda < 1]$ and $k(0) < 0$ for $[(p - c)(1 - \lambda) - \lambda s < 0$ and $\lambda < 1]$ or $\lambda > 1$. Moreover:

$$k'(Q) = \frac{\lambda(p + s - v)}{p - c + \lambda(c - v)}(1 - F(Q)) > 0$$

and:

$$k''(Q) = -\frac{\lambda(p + s - v)}{p - c + \lambda(c - v)}f(Q) < 0,$$

which implies that $k(Q)$ is concave and increasing. For $[(p - c)(1 - \lambda) - \lambda s < 0$ and $\lambda < 1]$ or $\lambda > 1$ let Q_{01} be such that $k(Q_{01}) = 0$. This implies that $D_1(Q)$ is equal to 0 on the interval $(0, Q_{01})$ and is an increasing function of the order quantity for $Q \geq Q_{01}$. Moreover, it tends to μ as Q tends to infinity.

For the upper limit, we have:

$$\begin{aligned} l(0) &= \mu, \\ l'(Q) &= -\frac{\lambda(p+s-v)}{(p-c)(1-\lambda)-\lambda s}F(Q), \\ l''(Q) &= -\frac{\lambda(p+s-v)}{(p-c)(1-\lambda)-\lambda s}f(Q). \end{aligned}$$

Let Q_{02} be such that $l(Q_{02}) = 0$. If $(p - c)(1 - \lambda) - \lambda s > 0$ and $\lambda < 1$ then the upper limit $D_2(Q)$ is decreasing for $Q \leq Q_{02}$ and equal to 0 for $Q > Q_{02}$, otherwise $D_2(Q)$ is increasing and tends to infinity as Q tends to infinity.

Additionally, for $[(p - c)(1 - \lambda) - \lambda s < 0$ and $\lambda < 1]$ or $\lambda > 1$ if:

$$D_2'(Q_M) - D_1'(Q_M) = 0,$$

then we infer that the minimum distance between the limit functions is attained for Q_M such that $F(Q_M) = [(p - c)(\lambda - 1) + \lambda s]/[\lambda(p + s - v)]$ (cf. Parlar and Weng, 2003).

Using the above properties, we obtain the approximate solution for the satisficing-level model which is later used in the bicriteria model. The next theorem holds for a risk-adjusted retailer. It is equivalent to the theorem for a risk-neutral retailer presented in Parlar and Weng (2003). In our case, the solution involves the risk coefficient and one more additional case occurs.

Theorem 2

1. If $[(p - c)(1 - \lambda) - \lambda s < 0$ and $\lambda < 1]$ or $\lambda > 1$ and if for some parameters p, s, v we have:

$$a(Q) < b(Q) \text{ for } Q > Q_M,$$

where $a(Q) = f(D_2(Q))/f(D_1(Q))$ and $b(Q) = \frac{\lambda s - (1 - \lambda)(p - c)}{p - \lambda v - (1 - \lambda)c} \frac{1 - F(Q)}{F(Q)}$, then the survival probability $H_\lambda(Q)$ is decreasing on (Q_M, ∞) and attains its maximum on the interval (Q_{01}, Q_M) .

2. If $(p - c)(1 - \lambda) - \lambda s > 0$ and $\lambda < 1$ then the survival probability $H_\lambda(Q)$ attains its maximum at Q_1 , defined by $E_\lambda(Q_1) - (p - c)Q_1 = 0$. Then the maximal survival probability is equal to $1 - F(Q_1)$.

Proof

It is enough to prove 2). In this case, the risk-adjusted profit function is an increasing function of the realized demand. Furthermore, $E_\lambda(0) = [(p - c)(1 - \lambda) - \lambda s\mu] > 0$ and, additionally, $E_\lambda(Q)$ is a convex function for all $Q > 0$. This implies that there exists Q_1 such that $E_\lambda > (p - c)Q$ for $Q < Q_1$, $E_\lambda < (p - c)Q$ for $Q > Q_1$ and $E_\lambda(Q_1) = (p - c)Q_1$. These inequalities are illustrated in Figure 3. Therefore, we have $D_1(Q_1) = D_2(Q_1) = Q_1$. Since $D_2(Q)$ is in this case a decreasing function of Q and $D_1(Q)$, an increasing function of Q , then using Theorem 1b we see that the optimal order quantity is Q_1 and the maximum survival probability is $H_\lambda(Q_1) = \int_{Q_1}^{\infty} f(x)dx$, which gives the desired result.

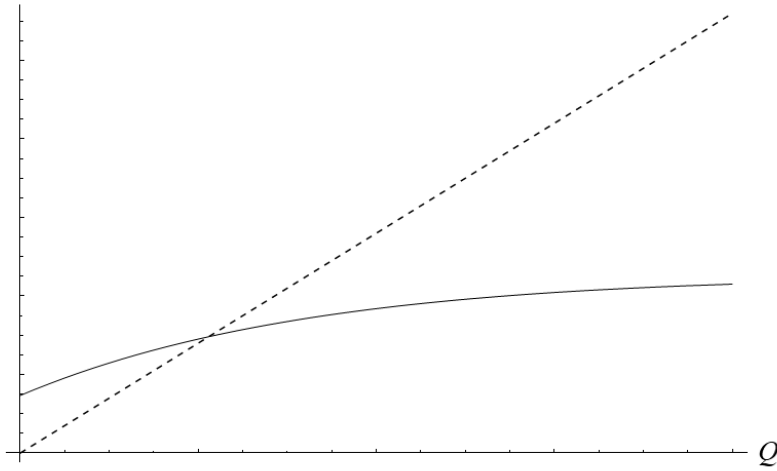


Figure 3. Functions: $(p - c)Q$ (dashed) and $E_\lambda(Q)$ (solid) for $(p - c)(1 - \lambda) - \lambda s > 0$ and $\lambda < 1$

Now we combine both objectives in the bicriteria newsvendor model. These objectives are mutually conflicting. For this reason, the bicriteria index $Y(Q)$ is used, which is defined by:

$$Y_\lambda(Q) = \frac{w}{E_\lambda^*} E_\lambda(Q) + \frac{1 - w}{H_\lambda^*} H_\lambda(Q)$$

(cf. Parlar and Weng, 2003). Let $E_\lambda^* = E_\lambda(Q_E^*)$ and $H_\lambda^* = H_\lambda(Q_H^*)$. Note also that both E_λ^* and H_λ^* are constants in the bicriteria function. The weight $0 \leq w \leq 1$ measures the relative importance of $E_\lambda(Q)$ and $H_\lambda(Q)$. Our aim is to find the order quantity which maximizes the bicriteria index. It can be considered as a compromise solution to the bicriteria problem. Let us recall that $Q_H^* < Q_E^*$ holds always and since the function $Y_\lambda(Q)$ is continuous, it attains its maximum on the interval (Q_H^*, Q_E^*) . The derivative of the bicriteria index is equal to

$Y'(Q) = \frac{w}{E_\lambda^*} E_\lambda'(Q) + \frac{(1-w)}{H_\lambda^*} H_\lambda'(Q)$ and it suffices to find Q_Y^* such that $Y'(Q_Y^*) = 0$ and then to prove that $Y''(Q) < 0$ for all $Q > Q_H^*$. As a result, we obtain a unique Q_Y^* dependent on λ which maximizes the bicriteria index and satisfies the inequality $Q_H^* \leq Q_Y^* \leq Q_E^*$. From now on we will write $Y^* = Y(Q_Y^*)$. Note that if the second derivative $H''(Q) > 0$ then $Y''(Q) < 0$ for the weight w such that:

$$w > \frac{E_\lambda^* H_\lambda''(Q)}{E_\lambda^* H_\lambda''(Q) - H_\lambda^* E_\lambda''(Q)},$$

where all $Q > Q_H^*$. The compromise solution optimal for the bicriteria problem can be found numerically.

3 The newsvendor problem with the risk-adjusted profit – exponential demand case

This section shows the results of the previous section for exponentially distributed demand. Exact solutions and numerical examples are given for demand with the density $f(x) = \alpha e^{-\alpha x}$, $x > 0$ and the cumulative distribution function $F(x) = 1 - e^{-\alpha x}$, $x > 0$, where $\alpha > 0$ is the parameter of this distribution. The mean demand is $\mu = \frac{1}{\alpha}$. In this case, the order quantity maximizing the risk-adjusted expected profit is $Q_E^* = \frac{1}{\alpha} \ln \frac{p+s-v}{c-v}$.

Since for the exponential distribution we have $Q_H^* = Q_{01} = Q_M$, which was proved in Bieniek (2016), the counterpart of the Theorem 2 is the following:

Theorem 3

If the demand distribution in the newsvendor problem is an exponential distribution with the parameter $\alpha > 0$, then the following statements hold.

1. If $[(p-c)(1-\lambda) - \lambda s < 0$ and $\lambda < 1]$ or $\lambda > 1$ and if for some parameters p, s, v we have:

$$a(Q) < b(Q) \text{ for } Q > Q_0,$$

where $a(Q) = e^{-\lambda(D_2(Q) - D_1(Q))}$ and $b(Q) = \frac{\lambda s - (1-\lambda)(p-c)}{p - \lambda v - (1-\lambda)c} \frac{e^{-\alpha Q}}{1 - e^{-\alpha Q}}$, then the survival probability attains its maximum value at $Q_H^* = \frac{1}{\alpha} \ln \frac{p+s-v}{c-v+(p-c)/\lambda}$ and this maximum value is equal to:

$$H^* = H(Q_H^*) = 1 - \left(\frac{\frac{p-c}{\lambda} + c-v}{p-v+s} \right)^{\frac{\lambda(p-v+s)}{(p-c)(\lambda-1) + \lambda s}}.$$

2. If $(p-c)(1-\lambda) - \lambda s > 0$ and $\lambda < 1$ then the survival probability attains its maximum at Q_1 , such that $E_\lambda(Q_1) - (p-c)Q_1 = 0$. Then $H^* = e^{-\alpha Q_1}$.

Now we illustrate the results of Theorem 3 with a graph. Figure 4 shows the graph of $H(Q)$ for the parameters $(\alpha, v, c, p, s) = (0.003, 15, 16, 30, 50)$. We assume that the risk coefficient is equal to 1.3, 1.0 and 0.7, respectively.

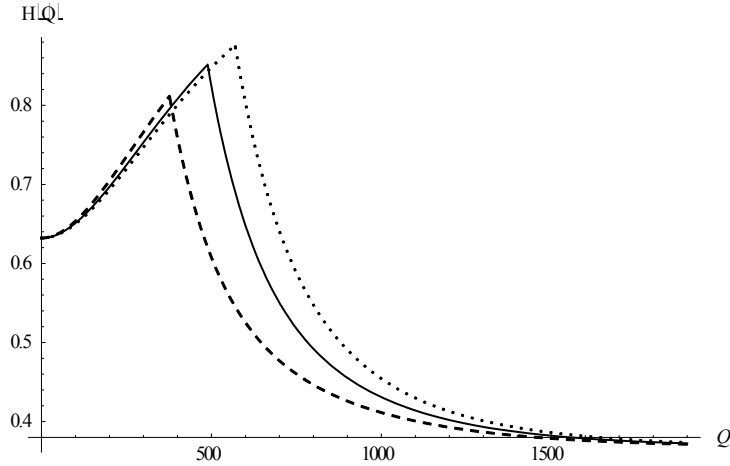


Figure 4. Survival probability $H(Q)$ for $(\alpha, v, c, p, s) = (0.003, 15, 16, 30, 50)$ with $\lambda = 1.3$ (dotted); $\lambda = 1.0$ (solid) and $\lambda = 0.7$ (dashed)

We conclude that for a more risk-averse retailer the order quantity maximizing the survival probability increases and the maximal survival probability also increases. Furthermore, for a more risk-seeking newsvendor the optimal order quantity decreases along with the optimal survival probability.

In what follows, we present a numerical example with the same parameter values. The optimal solution of the classical newsvendor model and the satisficing-level model are calculated separately, for various values of λ . The risk coefficient λ is fixed and varies from 0.2 to 1.3 with step 0.1.

Table 1: Sensitivity analysis for various parameters λ for $(\alpha, v, c, p, s) = (0.003, 15, 16, 30, 50)$

λ	Q_H^*	H^*	Q_E^*	E^*
0.7	376.622	0.8116	1391.46	3692.64
0.8	418.872	0.8274	1391.46	3553.5
0.9	455.889	0.8404	1391.46	3414.35
1.0	488.779	0.8514	1391.46	3275.2
1.1	518.334	0.8607	1391.46	3136.06
1.2	545.138	0.8688	1391.46	2996.91

Let us analyse the results presented in Table 1. We see that the optimal order quantity maximizing the risk adjusted expected profit is always larger (possibly even three-fold) than the solution of the satisficing-level model. If the risk coef-

ficient increases from 0.7 to 1.2 then the optimal order quantity maximizing the survival quantity increases from 376.622 to 545.138. Moreover, the optimal order quantity in the classical objective does not depend on the risk coefficient and remains constant, equal to 1391.46 for any λ . But both the maximum survival probability and the risk adjusted expected profit depend on the risk coefficient. The survival probability increases from 0.811 to 0.8688 if λ increases from 0.7 to 1.2. By contrast, the maximum risk-adjusted expected profit decreases from 3692.64 to 2996.91 for the increasing risk coefficient.

Now we show the results of a numerical example of the bicriteria problem. Note that the optimal order quantity Q_Y^* can be found numerically. We assume that the weight increases from 0 to 1 with step 0.1. The risk coefficient λ is set to 0.8, 1.0 and 1.2, respectively. We examine the sensitivity of the optimal solution with respect to weight w . The model parameters here are also $(\alpha, v, c, p, s) = (0.003, 15, 16, 30, 50)$. For these parameters to ensure the negativity of $Y''(Q)$, weight w should be greater than or equal to 0.5. For $w < 0.5$ we simply take $Q_Y^* = Q_H^*$.

Table 2: Sensitivity analysis for various values of weight w for $(\alpha, v, c, p, s) = (0.003, 15, 16, 30, 50)$

λ	0.8	0.8	1.0	1.0	1.2	1.2
w	Q_Y^*	Y^*	Q_Y^*	Y^*	Q_Y^*	Y^*
0.5	1300.06	0.7334	1310.09	0.7289	1317.43	0.7266
0.6	1333.06	0.7863	1339.52	0.7827	1344.2	0.7808
0.7	1354.96	0.8396	1359.01	0.8368	1361.93	0.8354
0.8	1370.6	0.893	1372.91	0.8911	1374.58	0.8902
0.9	1382.33	0.9464	1383.34	0.9455	1384.07	0.945
1.0	$Q_E^* = 1391.46$	1.0	Q_E^*	1.0	Q_E^*	1.0

We note that as weight w increases, the optimal order quantity maximizing the bicriteria index also increases. Moreover, for greater values of w the expected profit model has an increasing influence on the bicriteria model. For this reason, the optimal value Q_Y^* is closer to the optimal order quantity Q_E^* of the expected profit model. Otherwise, lower values of weight imply a greater influence of the satisficing-level model on the bicriteria model. Additionally, for $w < 0.5$ the order quantity maximizing the bicriteria index is assumed to be equal to the optimal order quantity maximizing the survival probability. All these statements hold for a certain fixed value of the risk coefficient.

4 Conclusions

Our paper deals with the bicriteria optimization in the newsvendor problem with various risk tolerance. First, we define the risk-adjusted profit function. The first objective investigated is the classical objective of the maximization of the expected profit but for the risk-adjusted profit. The second objective considered is the maximization of the probability that the risk-adjusted profit is greater than or equal to the risk-adjusted expected profit. We determine the solutions separately for each model and then we obtain the compromise solution with two conflicting objectives. The solution of the bicriteria problem can be found numerically. Since the results of the satisficing-level model in the general case are approximated, we use the exponential distribution to determine exact solutions. All the results strictly depend on the risk tolerance of the retailer. Namely, the solutions are different for a risk-averse, a risk-neutral, and a risk-seeking newsvendor. The sensitivity analysis of the changes of the risk coefficient is also performed.

Future research can include, for instance, the creation of new algorithms for the solution of this model. Other modifications of the profit target setting, taking into account the behaviour of the customer, could also bring interesting results.

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