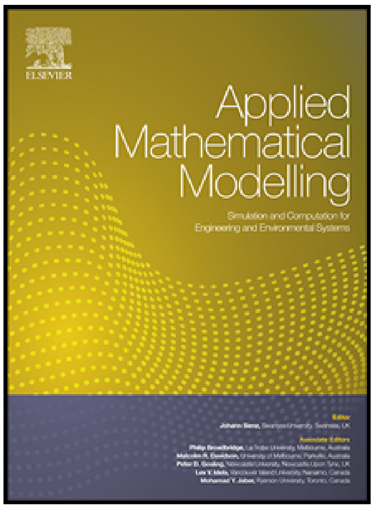
Accepted Manuscript



Service capacity procurement of logistics service supply chain with demand updating and loss-averse preference

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PII: S0307-904X(18)30462-1
DOI: https://doi.org/10.1016/j.apm.2018.09.020
Reference: APM 12472

To appear in: *Applied Mathematical Modelling*

Received date: 11 April 2017
Revised date: 30 August 2018
Accepted date: 11 September 2018

Please cite this article as: Weihua Liu , Meili Wang , Donglei Zhu , Li Zhou , Service capacity procurement of logistics service supply chain with demand updating and loss-averse preference, *Applied Mathematical Modelling* (2018), doi: https://doi.org/10.1016/j.apm.2018.09.020

Highlights

- Service capacity procurement of logistics service supply chain is analyzed.
- Demand updating and loss-averse preference are considered in four models building.
- The impact of loss-averse preference on supply chain member's decisions is studied.
- Conclusions are generated by four models comparison and numerical analysis.

Service capacity procurement of logistics service supply chain with demand updating and loss-averse preference

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Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this article.

ACKNOWLEDGEMENT

This research is supported by the National Natural Science Foundation of China (Grant No. 71672121, 71372156). The reviewersô comments are also highly appreciated.

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Abstract: This paper studies the impacts of loss-averse preference on the service capacity procurement decisions with demand updating in a logistics service supply chain, which consists of one logistics service integrator and one functional logistics service provider. It starts from a basic two-stage Stackelberg game model, then, extends to three scenarios where either the integrator or the provider or neither of them has loss-averse preference. The impact of loss-averse preference on the decisions of supply chain members is discussed by comparing the four models. Our results reveal, first, the loss-averse preferences do not always affect the decisions of supply chain members. If certain conditions are satisfied, the logistics service integrator can benefit from its loss-averse preference. Second, the increased service level can affect the logistics service integratorǿs procurement strategy and the functional logistics service providerǿs pricing strategy. This effect is only related to the loss-averse preference of the functional logistics service provider. Last, under certain conditions, the total service capacity decreases with the increased service level, regardless of whether or not the supply chain members have loss-averse preferences.

Key words: demand updating; loss-averse preference; procurement; service capacity; logistics service supply chain

1. Introduction

In recent years, e-commerce has been developing very quickly around the world and has created a massive demand for logistics. Majority of e-commerce companies outsource their logistics services, as it is very difficult for them to provide logistics services on their own. Thus, logistics service supply chain (LSSC) is formed. An LSSC usually consists of a logistics service integrator (LSI) and several functional logistics service providers (FLSPs), where LSI provides customized logistics services for e-commerce companies by integrating the service capacities of multiple FLSPs. FLSPs consist of traditional functional logistics enterprises, such as transportation and storage enterprises, among others. These FLSPs are integrated as the suppliers by the LSI when the LSI trying to provide the integrated services. For example, LSIs, such as China P.G. Logistics Group [1], Chinese Yuantong Express Logistics Company [2], and Robinson Global Logistics Co., Ltd. [3], purchase transportation capacity and storage capacity separately from different FLSPs to provide a systematic logistics service to customers. Accordingly, capacity procurement is an important part in LSSCs.

In practice, however, logistics service capacity procurement is not easy, especially when market demand updating and behavioral factors are taken into consideration [4]. For example, Chinese Yuantong Express Logistics Company, an LSI with more than 60 branches, provides integrated logistics services mainly to China Taobao Electronic Commerce. Taobao has their biggest sales promotion on November 11 annually. On November 11, 2015, the e-commerce turnover of Taobao was 91.217 billion RMB, 27.14 times that of the turnover in the corresponding period in 2011 [5]. All the branches of Yuantong collected 53,280,000 parcels (19.95 times of the parcels in the corresponding period in 2011) to be delivered to consumers located in 31 provinces in 3 to 5 days. To manage the sharp increase in logistics service demand, in October 2012, Yuantong pre-ordered capacity according to its demand forecast based on the e-commerce sales promotion, then purchased capacity for the second time in November when customer demand is realized [2]. If Yuantong finds that after updating the demand, the purchase quantity is too much, Yuantong will sell the remaining capacity at a lower price. However, the initial purchasing cost has been paid to his FLSP, which is regarded as a loss by Yuantong. On the other hand, it is expensive for his FLSP to expand their logistics capacity (such as purchasing transportation vehicles and constructing warehouses) if the logistics capacity is lower than the updating demand. Therefore, if Yuantong does not make use of the second purchasing opportunities to increase their purchasing capacity, his FLSP will be afraid that rush expansion of logistics capacity will cost too much and result in a loss of their profits. Consequently, the loss-averse preferences of both parties made it difficult for Yuantong to make effective decisions. Yuantong was under great pressure due to the sharply increased demand and FLSPô s inadequate service capacity preparation. Warehouse overflow, delayed delivery and damaged goods occurred. These problems were not resolved before the sales promotion period in 2015 [6]. This example reveals LSIô s problems in building a scientific supply chain procurement strategy under sharply increased demand [7, 8].

From the perspective of theory, issues about supply chain decisions under demand updating and loss-averse have been studied individually. For example, in the research of supply chain decisions under demand updating scholars use the two ordering opportunities strategy to analyze the supply chain strategy [9, 10], and practical issues under complicated environments are explored [11-14]. Studies of strategies in supply chain with loss-averse mainly focus on supply chain coordination [15, 16] and inventory management [17] in manufacturing companies. The most relevant papers for this study are Ma et al. [18] and Qin [19], both of which take market demand updating and loss aversion preference into consideration. Ma et al. [18] built a model by punishing retailers who do not gain target profits and they provided optimal purchasing strategies for retailers. It focused on the fashion supply chain, but did not consider the properties of service and the combination of supply chain membersô loss aversion preferences. Qin [19] studied a loss-averse supplier under a push contract and a pull contract. This paper differs from Qin [19] in that this article mainly focuses on the related decision-making problems, such as pricing and ordering quantity in the logistics service supply chain instead of coordinating the supply chain.

In addition, Service Only Supply Chain is a supply chain system in which the ñproductsò are pure services, and physical products do not play a role, such as therapy, health care exams, financial consulting and fortune telling [20]. Logistics service supply chain is Service Only Supply Chain in the logistics field. The LSI purchases logistics service capacity, such as transport capacity and storage capacity, from FLSPs. After integration, the LSI sells the integrated logistics service capacity to customers. Therefore, different from the previous literature about the supply chain decisions in manufacturing companies, this paper considers two important characteristics of the service supply chain. One is inseparability and the other is perishability: service production and consummation always occur simultaneously, and the service capacity cannot be stored after the selling season [21]. Under demand updating, market demand is not realized in the first stage, thus procurement of the LSI in the first stage is a pre-order and the FLSP does not hand over the functional service capacity to the LSI. While in a manufacturing supply chain, a retailer can purchase and store a product for selling.

The service level is the other important property of service. The LSI and FLSP must pay an additional cost to guarantee the service level required by customers. The service-level guarantee cost will be explained in detail in Section 3. Liu et al. [22], also relevant to this paper, considers demand updating and service quality guarantees when developing logistics service purchasing strategies. However, our paper focuses on pricing and ordering quantity problems in an LSSC and considers two important properties of service, which are inseparability and perishability.

Accordingly, this paper attempts to explore the impact of the loss-averse preference on the LSIȏs order quantity and the FLSPȏs pricing strategy under demand updating, and tries to answer the three following questions:

(1) How do the loss-averse behaviors of the LSI and FLSP affect the pricing and purchasing decisions? What if only one of the supply chain members has a loss-averse preference?

(2) Do the loss-averse preferences of the LSI and FLSP definitely affect the optimal decisions of supply chain members? If not, what are the conditions?

(3) Are there interactions between the loss-averse preference of the LSI and that of the FLSP? If so, what are the interactions?

To answer the questions above, we consider a two-echelon LSSC consisting of a loss-averse FLSP and a loss-averse LSI that purchase logistics service capacity from the FLSP before and after demand updating (Supply chains often contain multiple LSIs, FLSPs and customers, LSIs and FLSPs cooperate to satisfy the customer demand, therefore the roles of LSIs and FLSPs are often discussed emphatically. Similarly, this study aims to explore the impact of the loss-averse behavior of supply chain members, and we also focus on LSI and FLSP). We build a basic model to maximize the utilities of the LSI and FLSP who both have loss-averse preferences. But in practice, there are special scenarios where only one side has loss-averse preference or neither side has loss-averse preference. These special scenarios include: (a) only the LSI has loss-averse preference, (b) only the FLSP has loss-averse preference, and (c) neither of them has loss-averse preference (the detailed cases can be seen in section 4.2). After comparing the LSIȏs optimal procurement strategy and the FLSPȏs optimal pricing strategy among the basic model and the three scenarios above, the impact of the loss-averse preference on making the optimal decision is analyzed. In doing so, our paper makes the following three contributions: First, this paper takes both demand updating and loss-averse preference into consideration, exploring the interaction mechanism and a combination of these factors. Second, the current literature only considers the situation of one supply chain member having loss aversion behavior and studies the effects of loss aversion behavior in the case of complicated factors, such as asymmetric information [23] or sudden disruptions [24]. Conversely, this paper takes the loss aversion behavior of both the LSI and FLSP into consideration and explores the effects of loss-averse preferences with four combinations on supply chain decision making by comparing the optimal decisions in the basic model and three special cases. Third, this paper generates some unexpected conclusions. For example, the LSI can benefit from its loss-averse preference if certain conditions are satisfied. Additionally, the loss-averse preferences of the LSI and FLSP do not always affect the decisions of supply chain members.

The rest of the paper is organized as follows. Section 2 reviews the recent relevant literature. Section 3 provides the background for our study and develops a few necessary hypotheses. Section 4 builds a basic model (model I) and three special scenarios. By comparing the basic model with the three scenarios, Section 5 discusses the effects and interactions of the loss-averse preference of the LSI and that of the FLSP. Section 6 is a numerical analysis. Section 7 provides conclusions, management insights, and future directions for research.

2. Literature review

The topics most relevant to our study are LSSC capacity procurement, market demand updating, and loss-averse preference. The most relevant existing literature related to these three aspects will be reviewed in Sections 2.1 to 2.3.

2.1 Supply chain coordination under demand updating

Current studies of supply chain coordination under demand updating focus on two aspects. One is the expression of demand updating. The other is two-stage ordering policies in supply chain under demand updating. The Bayesian updating method [12], conditional distribution method [25], and AR(1) process [10] are widely used to perform demand updating.

The more complex two-stage ordering policy based on the demand information updating has been paid increasing attention by researchers. Gurnani and Tang [9] studied a retailer ordering a seasonal product prior to a single selling season, and improved the forecast by updating demand and presenting a nested news vendor model for determining the optimal order quantity. Afterwards, many scholars extended the issue to more complicated situations, such as allowing retailers to purchase from external markets, studying single and multi-period quantity flexibility contracts in a spot market and discussing the impact of the forecast quality and the level of flexibility on the optimal decisions [11]. Based on this, service levels are considered [26]. Because the decision-making processes of supply chain members are often subject to various conditions, capacity constraints [13] and capital constraints [14] are introduced into the two-stage ordering policy.

With the rapid change of market, such as e-coherence market in recent years, demand updating began to be incorporated into service capacity procurement decisions. For example, Liu et al. [22] studied the logistics service supply chain and explored the influence of demand uncertainty revelation and quality guarantee change cost on the supply chain membersô optimal decision making by comparing the four combinations of uncertainty complete revelation/uncertainty incomplete revelation (UCR/UIR) and GCC/no guarantee change cost (NGCC). The differences between this paper and Liu et al. [22] are in three aspects. First, in Liu et al. [22], the LSI purchases and sells service capacity in both periods, however, we study a one-period-two-stage process in which the LSI purchases service capacity in both stages, but only sells at the end of the second period. Second, although this paper and Liu et al. [22] both consider demand updating, this paper focuses on the purchasing quantity and pricing problem given two purchasing opportunities, while Liu et al. [22] attempted to determine the effects of the demand uncertainty revelation degree. Third, Liu et al. [22] studied the service quality guarantee, while we study loss aversion behavior.

2.2 Loss-averse preference

Behavioral operations in supply chains have been developed very fast recently and many behaviors have been considered in the literature [27]. As one typical behavior, studies of loss-averse preference have shown that people are more averse to losses than they are attracted to the same-sized gains [18]. To extend the literature on supply chain, loss-averse has been introduced into the current supply chain decision-making models that focus on supply chain coordination with uncertain demand [15] and inventory management [19]. On one hand, scholars usually use contracts to solve the supply chain coordination problem with uncertain demand. for example, Wang and Webster [28] considered a decentralized supply chain and found that a special class of distribution-free GLB contracts exist to improve supply chain performance. Li et al. [29] conducted a mean variance (MV) analysis of a fast fashion supply chain consisting of one supplier and n risk averse retailers. They determined that a simple return contract can be sufficient to achieve coordination. On the other hand, in the study of the inventory management, loss-averse preference has also drawn the attention of scholars studying more complex factors, such as asymmetric information [23], sudden disruptions [24] and consumer loss aversion [30]. However, the current literature on the loss-averse preference has mainly focused on retailers [31] or manufacturers [32] in manufacturing supply chains, rather than on supply chain members in service supply chain. In practice, supply chain members often have loss-averse preferences. It is common for both supplier and retailer have loss-averse, it is more realistic to consider that both members have loss-averse preferences than to consider that a single supply chain member has loss-averse preference. Obviously, it is more likely to show the complicate influence mechanism and obtain the cross-effects of both membersô loss-averse preferences.

Recently, interdisciplinary studies of demand updating and loss-averse preference have been conducted. Some scholars, such as Ma et al. [18] and Qin [19] have conducted exploratory studies. Ma et al. [18] built models by punishing decision makers (retailers) for not reaching their target profits. They found that the optimal first-stage order quantity decreases as the penalty coefficient increases. The optimal first-stage order quantity always decreases as information is more accurate. However, their models focused on demand updating in the fashion supply chain and did not consider the combination of loss-averse preferences of the LSI and FLSP. Qin [19] studied how the supplierôs loss-averse preference and information updating affect the push contract and pull contract, but it did not focus on LSSCs. Qin [19] discovered that with no additional information updating, there is no difference between the push contract and the pull contract for any wholesale price and the loss averse supplier. In addition, Chiu and Choi [33] studied the use of the mean-variance (MV) theory in multi-echelon supply chain problems and supply chain problems with information updating, to provide a better method to conduct the interdisciplinary studies of demand updating and loss-averse preference.

2.3 Summary of literature review and model orientation

From sections 2.1 and 2.2, it can be seen that demand updating and loss aversion have a crucial impact on supply chain decision making. Although the current research on supply chain demand updating and loss aversion is relatively abundant, the majority of current researches mainly focus on the manufacturing supply chain. Few scholars have focused on the influences of demand updating and loss aversion in the service supply chain. The most relevant research to this article is the study by Ma et al [18], Qin [19] and Liu et al. [22]. Ma et al [18] and Qin [19] consider both market demand updating and loss aversion by supply chain members. However, Ma et al [18] focus only on the fashion supply chain, but do not address the logistics service supply chain, service feature factors, and the behavioral mix of different members. Qin [19] only studies the contract coordination problem and does not consider the product pricing and order quantity decision-making problems and the service product features. Liu et al. [22] consider logistics service capacity purchasing decisions under the demand uncertainty revelation and quality guarantee change but do not consider the loss-averse behavior of supply chain members.

In this paper, the research will focus on these issues and study service supply chain procurement capabilities in depth. We will build the service capacity purchasing model with a combination of loss aversion behavior to maximize the utility of the LSI and FLSP under demand updating and at a given service level. We obtain the optimal purchase quantity of the LSI and the optimal pricing strategy of the FLSP in different situations and analyze the effects of market demand updating and loss aversion on the optimal decision.

3. Problem description and assumptions

In this paper, we consider a two-echelon LSSC in which an LSI purchases logistics

To find out the relationship among the optimal strategies of the LSI and the FLSP in the second stage, we first solve simultaneous Eq.(C.1) and Eq. (C.2)

$$Q_2 \quad F^{1}(\frac{p \quad b \quad w_2}{p \quad b \quad s} | x_e) \qquad \text{Eq. (C.1)}$$

$$w_2 \quad (Q_2 \quad) f(x | x_e)(p \quad b \quad s) \quad (1 \quad) \qquad \text{Eq. (C.2)}$$

Let $G \; w_2 \quad F(\frac{w_2 \quad 1}{f \;\; x | x_e \quad p \quad b \quad s} \quad | x_e) \quad \frac{p \quad b \quad w_2}{p \; b \; s}$ Eq. (C.3)

$G \; w_2$ is a function of w_2. Take the second derivative of w_2 we can get:

$$\frac{G(w_2)}{w_2} \quad \frac{2}{p \quad b \quad s} \quad 0 \qquad \text{Eq. (C.4)}$$

Eq. (C.4) shows that $G(w_2)$ is the strictly monotone increasing function of w_2 and $w_2 \quad (w_l, w_h)$. To ensure that there is at least one solution of w_2 which satisfy the equation (C.3), the following conditions should be satisfied: when $w_2 \quad w_l$, $G(w_l) \quad 0$ and when $w_2 \quad w_h$, $G(w_h) \quad 0$. Thus the w_2 which makes $G(w_2) \quad 0$ is the one and only optimal wholesale in the second stage. It means that: $Q_{2L} \quad Q^{\bullet}_{2L} \quad Q^{€}_{2L} \quad Q^{\bullet}_{2L}$; $w_{2L} \quad w^{\bullet}_{2L} \quad w^{€}_{2L} \quad w^{\bullet}_{2L}$

Appendix D. Proof of Theorem 2

When , $F \;\; x | x_e$ is strictly monotone increasing function:

$$F \;\; Q^{\bullet}_{1H} | x_e \quad F \;\; Q^{\bullet}_{1H} | x_e$$

Besides, $Q^{I}_{1H} \quad k \quad 1 \quad Q^{III}_{1H} \quad k \quad 1$

So we only consider when $k \quad 1$. We can get:

$$Q^{I}_{1H} \quad Q^{III}_{1H} \quad 1 \quad k \quad p \quad b \quad s \quad f \;\; x | x_e \quad Q^{I}_{1H} \;\; kpf \quad x \quad kp \; 1 \quad F^{I} Q_{1H} \quad 2$$

As $Q^{I}_{1H} \quad Q^{III}_{1H} \quad 0$ È $2 \quad Q^{I}_{1H} \; kpf \quad x \quad kp \; 1 \quad F \;\; Q_{1H}$

Let $H(m) \quad mkpf(x) \quad kp(1 \quad F(m))$ and take the second derivative of on

$H(m)$, we can find out that $H(m)$ decreases with and $H(m)_{max}$ $H(\ )$.

Thus, when 2 $kpf(x)$ $kp(1$ $F(\ ))$, .

Appendix E. Proof of Theorem 3

When k 1, w_{1H}^{*} w_{h} and w_{1H}^{*} w_{1H}^{*}

When k 1: If w_{1H}^{*} w_{1H}^{*} and theorem 2 is satisfied,

$$\frac{kpf(x)}{1\ \ k}\ \ \frac{(2\ \ k)(p\ \ b\ \ s)\ f(x|x_e)}{k\ \ 1} Q_{1H}^{I}\ \ Q_{1H}^{I}\ \ Q_{1H}^{II}\ \ p\ \ b\ \ s\ \ f\ \ x|x_e\ \ 0$$

As k 1, $kpf(x)$ $(2\ \ k)(p\ \ b\ \ s)\ f(x|x_e)$ 0

Appendix F. Proof of Theorem 5

From Scenario III, when neither of the LSI and the FSLP has no loss-averse and q 0

$$Q_{2L}^{*}\ \ F^{1}\left(\frac{p\ \ b\ \ w_{2}^{*}}{p\ \ b\ \ s}\,|\,x_e\right)$$

and w_{2L}^{*} $(Q_{2L}^{*}$ $)\ f(x|x_e)(p\ \ b\ \ s)$ $(1$ $)$

take the second derivative of γ on Q_{2L}^{*} and w_{2L}^{*} respectively, we can get:

$$\frac{w_{2L}^{*}}{}\ \ \frac{}{2f(x|x_e)(p\ \ b\ \ s)}\ \ 0,\ \ \frac{w_{2L}^{*}}{}\ \ \frac{1}{2}$$

If 0 $\frac{1}{2}$, $\frac{w_{2L}^{*}}{}$ 0 , If $\frac{1}{2}$ 1, $\frac{w_{2L}^{*}}{}$ 0

Similarly, when q 0, $\frac{Q_{1H}^{*}}{}$ 0

and if 0 $\frac{1}{2}$, then $\frac{w_{1H}^{*}}{}$ 0 . If $\frac{1}{2}$ 1, then $\frac{w_{1H}^{*}}{}$ 0.

We can get the same conclusion from Scenario I.

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