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## Incentives to improve the service level in a random yield supply chain: The role of bonus contracts



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### ABSTRACT

We consider a decentralized supply chain comprised of one manufacturer and one retailer where the manufacturer has random yield, and the retailer faces uncertain demand. To guarantee product availability, the retailer requires a service level of the product supply from the manufacturer. However, we determine that the high service level indeed benefits the retailer whereas causes the manufacturer's profit loss. Therefore, to promote the high-service-level cooperation, the retailer has to provide incentives for the manufacturer, such as bonuses. We consider two common bonus contracts: unit bonus and flat (or lump-sum) bonus. The primary question we address is whether the service-level based bonus contracts can achieve the two firms' Pareto-improving for both service level and profits, which is a prerequisite for the retailer to carry out them with the manufacturer. The results show that both bonus contracts can achieve Pareto-improving. While it is simpler for the retailer to carry out the unit bonus contract, the retailer can achieve a higher service level and higher profits under the flat bonus contract.

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### 1. Introduction

Given the increasingly intense global market competition, improving service level has become one of the “top two goals” for supply chain management (Chen & Shen, 2012; Gyorey, Jochim, & Norton, 2010). High customer service level plays an important role in enhancing competitiveness and continuous development for the entire supply chain. Fortunately, firms gradually identify this key point. According to the description of KPMG (2010), in the food, drink, and consumer goods (FDCG) industry, retailers often enter into a service-level agreement with their FDCG manufacturers. Additionally, in the automotive industry, many original equipment manufacturers cooperate with their first-tier suppliers under service-level contracts (Stratmann, 2006).

However, high degree supply chain risk, including supply and demand uncertainty, hinders the achievement of a high service level. A survey by McKinsey finds that 82 percent of the respondents in developed Asian countries claim that the supply chain risk will continue to increase in the next five years (Gyorey et al., 2010). Therefore, product availability, which is critical in keeping customers satisfied in the uncertain operations environment, is emphasized in service-level based contracts between supply chain parties. Based on these contracts, the upstream suppliers must achieve an ample supply with

a certain probability (Chen & Shen, 2012; KPMG, 2010; Stratmann, 2006).

Although the high service level benefits the entire supply chain with respect to customer satisfaction, it may cause ineffective operations for the upstream parties. This problem is highly serious when the product has a short life cycle and random yield. Therefore, the service-level contracts between the supply chain parties should emphasize not only achieving a high service level but also providing the incentives (such as bonuses) for the contractors to improve performances (Tarakci, Tang, Moskowitz, & Plante, 2006). This observation stems from the business practice of the leisure food chain store companies in China, such as LPPZ Foods. LPPZ Foods is an emerging and rapidly developing chain store company that purchases products from a large number of food manufacturers, including some seasonal perishable products with short life cycles such as green bean cake, zongzi, and mooncake. To guarantee product availability, LPPZ Foods measures the service level of the manufacturers and provides bonuses for the manufacturers with relatively high service levels.<sup>1</sup> However, the lack of quantitative decision analysis hinders retailers such as LPPZ Foods from taking full advantage of service-level based bonus contracts to improve the performance of the entire supply chain.

The above discussion gives rise to three new quantitative research questions. Specifically, we elaborate them as follows. First, facing

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<sup>1</sup> We observe this phenomenon through the field survey and interview in a co-operation project with LPPZ Foods. Visit the website to learn more about LPPZ: <http://www.517lppz.com/>.

the supply and demand uncertainty, how does the retailer use the two common bonus regimes (i.e., unit bonus and flat or lump-sum bonus) to motivate the manufacturer to improve the service level? Second, can service-level based bonus contracts achieve the two parties' Pareto-improving? Third, what are the differences between the flat bonus contract and the unit bonus contract?

To address the above issues, we construct a decentralized supply chain that consists of a manufacturer and a retailer. The retailer faces a single-period uncertain demand for a short life-cycle product and places an order with the manufacturer. The manufacturer is responsible for the production of the product, wherein the production process contains the random yield problem. To guarantee product availability, the retailer cooperates with the manufacturer under a service-level based bonus contract. The retailer requires the manufacturer's product supply to reach a service level, defined as the probability of meeting the order quantity. Once the order is met, the manufacturer can receive a bonus payment from the retailer. There exist two bonus contracts for the retailer to use: a unit bonus contract and a flat bonus contract. A unit bonus contract means the manufacturer receives a unit bonus for every leftover product exceeding the retailer's order quantity, whereas with a flat bonus contract, the manufacturer acquires a fixed bonus when the order quantity is met.<sup>2</sup>

By analyzing the equilibrium strategies of the two parties, we find some interesting results that contribute to the extant literature in the following ways. First, our model involves both the supply and demand uncertainties, which are major issues of concern in recent literature. However, our investigation is from a new perspective that highlights the impacts of service level on the two firms' performances. It is useful for the entire supply chain to maintain a high competitive advantage under these two common risks. Second, we analyze the influence of a bonus on the two firms' cooperation with a service-level requirement. The results show that the bonus plays the role of an incentive for the random yield manufacturer to improve the level of service. More importantly, under certain business conditions, bonus contracts can help the two firms achieve Pareto-improving for service level and profits. Third, our paper compares two potential bonus contracts, the unit bonus contract and the flat bonus contract, thus providing managerial insights for the retailer to choose an appropriate contract under different operation situations.

The remainder of this paper is organized as follows. [Section 2](#) reviews relevant literature. In [Section 3](#), we describe the problem's formulation and notations. The basic model without a bonus is analyzed in [Section 4](#). [Section 5](#) and [Section 6](#) discuss the unit bonus contract and flat bonus contract with a service-level requirement, respectively. [Section 7](#) illustrates comparisons between the unit bonus contract and the flat bonus contract. We present this paper's conclusions in [Section 8](#). All mathematical proofs are provided in the online Appendix.

## 2. Literature review

Our paper is closely related to the stream of literature on random yield effect in two-level decentralized supply chains with short life-cycle products. There exist two possible categories in this research. One category focuses on the ex ante contract design, order and production decisions of the supply chain to mitigate the random yield risk. For example, [Keren \(2009\)](#) and [Li, Li, Cai \(2012\)](#) consider the order and production decisions in a random yield supply chain with known demand. The difference is that [Li et al. \(2012\)](#) study a more

generalized distribution of yield randomness. [Wang \(2009\)](#) compares the role of traditional and vendor-managed-inventory arrangements between a manufacturer and a distributor in mitigating the random yield risk. [Li, Li, Cai \(2013\)](#) explore the double marginalization effects in a random yield decentralized supply chain and design coordination contracts to improve the supply chain performance. [Arifoğlu, Deo, and Irvani \(2012\)](#) study an influenza vaccine supply chain that faces yield uncertainty and self-interested consumers. They find that more efficient and less uncertain allocation mechanisms can improve supply chain efficiency. [Tang Kouvelis \(2014\)](#) design a pay-back-revenue-sharing contract to coordinate a supply chain with random yield.

The other category studies the replenishment policy to respond to the realized random yield risk. [He Zhang \(2008\)](#) and [Xu \(2010\)](#) explore how emergency production for the random yield supply chain replenishes the shortage of products. [He Zhang \(2010\)](#), [Kazaz Webster \(2011\)](#) and [Ma, Yin, Guan \(2013\)](#) consider the replenishment from the open market (e.g., spot market and secondary market) for the supply chain parties to mitigate the yield risk. In addition, [Inderfurth Clemens \(2014\)](#) and [Cho and Tang \(2013\)](#) simultaneously consider the situation with and without replenishment when the random yields are realized. While [Inderfurth Clemens \(2014\)](#) focus on the deterministic demand problem with the risk sharing contracts, [Cho and Tang \(2013\)](#) study the advance selling strategy under uncertain demand.

Our research falls within the first category. Different from the aforementioned papers, we consider the service-level requirement between a manufacturer and a retailer, which consists of an agreement for the supply chain to improve product availability and to keep customers satisfied. However, the manufacturer may have to sacrifice the optimal decision under the constraint of the service level, which makes achieving a high level of service extremely difficult. Therefore, the second difference is that we focus on the possibility of whether the retailer can use the bonus contracts to motivate the manufacturer to improve the level of service and to achieve Pareto-improving of the two firms' profits.

Our work is also related to the stream of literature on service-level requirements in supply chain management. There exists extensive literature on the service-level agreement in a two-echelon inventory system under periodic review ([Bollapragada, Rao, & Zhang, 2004](#); [Katok, Thomas, & Davis, 2008](#); [Lejeune, 2013](#); [Liang Atkins, 2013](#); [Sieke, Seifert, & Thonemann, 2012](#)). For the single-period problem which is more strongly related to our research, [Sethi, Yan, Zhang, and Zhou \(2007\)](#) consider a supply chain wherein the buyer has two procurement opportunities under a service-level constraint and information update. They show that the buyer's critical market signal, optimal first-stage order quantity, and the optimal expected profit all have a monotone relationship with the service-level target. Without any information update, [Chen and Shen \(2012\)](#) analyze the influence of an option contract on a two-party supply chain with a service requirement and show that the option contract benefits both the retailer and the supplier. [Li, Huang, Cheng, Zheng, and Ji \(2014\)](#) consider a decentralized supply chain wherein the retailer commits a service level for the after-sales service to consumers and study the impacts of the make-or-buy service capacity decision. All the three studies consider a reliable supply process; therefore, the service-level requirement comes from the customers. However, as we consider a random yield manufacturer, the service-level requirement is established between the retailer and the manufacturer. Thus, we focus on whether the two parties can achieve Pareto-improving for both service level and profits under the impacts of supply uncertainty. Only [Wang, Xiao, Yang \(2014\)](#) consider an unreliable supply process and the downstream manufacturers' incentives to improve the upstream supplier's service level, which is more related to our study. However, the difference is that they focus on two manufacturer's horizontal competition, while we study the cooperation between the upstream party and the downstream party in the supply chain. Using the case without a service-level requirement as a benchmark, we study whether the two parties

<sup>2</sup> In the random yield supply chain, the definition of the unit bonus contract between the manufacturer and the retailer is similar to the over-production risk sharing contract, which is investigated by [Inderfurth Clemens \(2014\)](#) and [He Zhang \(2008\)](#). It is also similar to the additional marginal payment, which is considered by [Sohoni, Chopra, Mohan, and Sendil \(2011\)](#).

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