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# A revenue-sharing option contract toward coordination of supply chains

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ABSTRACT

In this paper, a novel mixed revenue-sharing option contract is introduced to coordinate a retailer–manufacturer supply chain. A European call option mechanism and a revenue-sharing mechanism are combined to cover drawbacks of the classic contracts. The option can increase the profit of the chain and the revenue-sharing can reduce double marginalization effects. In addition, an instantaneous purchase and a shortage penalty mechanism are introduced. The proposed mixed contract is modeled through a game theoretic approach to examine several possible situations in order to obtain the order quantity of the retailer and the production quantity of the manufacturer in the Nash equilibrium. Also, both the retailer and the manufacturer are considered as the leader of the chain to recommend an appropriate contract conditions for various types of industries and markets. Finally, the best conditions for achieving the supply chain coordination are provided in different situations. Results also demonstrate that the mixed contract dominates a wholesale and a basic option contract. The proposed coordination mechanism is applied in a real fashion apparel supply chain in Iran and a comprehensive sensitivity analysis is implemented on some parameters of the contract to provide some managerial insights for the supply chain members.



## 1. Introduction

Supply management plays a remarkable role in a supply chain (SC) because it influences profit of members of the SC. Today's fluctuating economies require considering uncertainties and risks associated with several parameters. Several types of risks have been identified threatening SCs from several resources while an appropriate risk hedging strategy mitigates the effects of them through following two stages: recognition of source of uncertainty in the network and individualization of the most correct way for reducing such level of uncertainty (Cucchiella and Gastaldi, 2006). Risks in SCs have been classified from different points of view. Supply network design, supplier relationship, supplier selection process, supplier order allocation and supply contract are the most critical areas which risk hedging policies could be applied (Tang, 2006). The current study focuses on the supply contract as a critical area in a SC since it can improve the profit of the whole SC.

The supply contracts indicate the parameters (such as quantity, price, time and quality) for a supplier to satisfy the demand of a buyer (Gan et al., 2009). In other words, a supply contract is a coordination mechanism that provides incentives to all the parties so that the decentralized chain behaves as nearly or exactly the same as the integrated one (Tsay, 1999). In traditional supply contracts, partners across the SC make decisions, independently, or make their decisions so that maximize their own profit. Both of these strategies can lead to local optimum solutions which may provide lower total profit for the SC (Bresnahan and Reiss, 1985; Lee et al., 1997; Li et al., 2013; Corbett et al., 2004). Other issue which is created by local optimum decisions is double marginalization. It occurs if both parties charge a markup which will result a higher final retail price and a lower total demand in comparison with vertically integrated contracts. In contrast, SC coordination improves the profit of the SC. To achieve a perfect coordination, participants must work as a unified system. SC coordination could be achieved via several approaches including SC contracts, information technology, information sharing and joint decision making (Kanda and Deshmukh, 2008). In this paper, the SC is coordinated via a supply contract.

Several types of coordination contracts have been introduced in the literature. The basic contracts include buyback, revenue-sharing, and quantity flexibility on which other types of contracts are based (Chopra and Meindl, 2007). In a revenue-sharing contract, the supplier sells products to the buyer at a low wholesale price and gets a fraction of revenue of the buyer instead. The concept of the revenue-sharing mechanism is incorporated in the proposed

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contract in this paper.

In addition to the common contracts listed above, option contract as another coordination mechanism has been recently introduced (Huang, 2009; Zhao et al., 2013; Gomez_Padilla and Mishina, 2009; Burnetas and Ritchken, 2005; Nomikos et al., 2013). The option contract is based on a financial derivative called an option. Large amount of uncertainties of prices in the financial markets has made the financial risk hedging tools the most powerful ones. Therefore, the option mechanism, as the most well-known financial derivative, is used as a supply contract in operations management. Two types of the option contracts are put and call options. A call option gives the holder of the option the right to buy an asset by a certain date at a certain price (Hull, 2012). The important parameters of the option contract are an expiration date (maturity) of the contract, an option price as a fee that the buyer pays for each purchased contract, and exercise price as the final price of the underlying commodities which the buyer will pay at the time of exercising. In a European option, the buyer could exercise the option only at the maturity of the contract. Unlike the financial options, which use the price feasibility as the condition of an option exercising, the real options use both the existence of demand and the price feasibility as the sufficient conditions of an option exercising. To mitigate the double marginalization effects, which could not be avoided by the option mechanism, a revenue-sharing mechanism is incorporated into the option mechanism. Moreover, two novel mechanisms are added to the basic definition of the contracts. The first one allows the retailer to purchase the extra products of the manufacturer in a higher price during the selling season. The second one fines the manufacturer if he cannot meet his commitments to the retailer.

In this paper, a mixed mechanism is introduced which aims at coordination of a retailer–manufacturer SC. In the proposed framework, the demand and the price of the underlying commodity are assumed to be stochastic. In the proposed contract, the manufacturer charges a low exercise price and gets a fraction of the revenue of the retailer at the end instead. The coordination mechanism is modeled as a Stackelberg game in which the order quantity of the retailer and the production quantity of the manufacturer are strategies of the members. The Nash equilibrium of this game provides optimal strategies of the parties. Moreover, as the optimal strategies of the parties strongly depend on the leader of the chain, both the retailer-led and the manufacturer-led situations are modeled. The mixed coordination mechanism is applied in real-world case study. A fashion apparel SC is considered in which a company produces clothing (i.e., the manufacturer) and another company sells the products in the final market (i.e., the retailer). A hypothetical centralized SC is also investigated to show the perfect coordination situation. Moreover, a wholesale contract is applied to the SC to obtain a nadir solution for the coordination problem. The final results are compared with the centralized SC and the wholesale contract to evaluate the performance of the novel mixed contract. A number of sensitivity analysis are also implemented to validates the performance of the model and provide some managerial insight for decision makers.

Remaining of the paper is organized as follows. In Section 2, a review of the literature in several types of contracts is presented. In Section 3, the game theoretic model is presented in cases of the retailer-led, the manufacturer-led, and the centralized SC. The mixed contract is analyzed in a real-world case study in fashion apparel sector in Section 5. A comprehensive sensitivity analysis is also implemented in this section and some concluding remarks and directions for future extensions are presented in the last section.

## 2. Literature review

The critical role of the supply contracts in economic relations causes a new research stream in the SC management. Although several types of contracts are introduced in the body of literature in economic studies, few previous studies investigate the supply contracts within the SC settings. Review papers in supply contracts have categorized them from several points of view. Tsay et al. (1998) addresses a qualitative overview of several types of the contracts under the deterministic or stochastic demand. Also, Lariviere (1998) provides a quantitative analysis of various types of contracts when the demand is random. SC coordination conditions and the role of supply contracts to achieve coordination are addressed in Cachon (2003). Although all the basic contracts create some advantages for the parties, there are some shortcomings which may stimulate the parties to use wholesale contracts without any coordination mechanism. Therefore, hybrid contracts are proposed to remove the shortcomings of the pure basic contracts. In this regard, the literature review is divided to three following parts: option contracts, revenue-sharing contracts and hybrid contracts.

### 2.1. The option mechanism

Option mechanism as the most well-known financial derivative, has been recently utilized as a risk-hedging contract in SCs. A growing number of studies have investigated it under different assumptions while in the most of them the SC is assumed to involve two echelons. Wang and Tsao (2006) introduce a single-period bidirectional option contract within which the retailer can increase or decrease the order quantity after the demand realization. They analyze the problem from the buyer's perspective and show that their proposed contract can increase the profit of the buyer. A retailer-led option contract is modeled by Wang and Liu (2007) in which the retailer aims to indicate the upstream production quantity via the proposed contract. Their results show that the proposed contract improves profit of both parties of the SC. Jiao et al. (2007) model several types of uncertainties in a production environment of a flexible manufacturing system through an option contract. They model the uncertain demand as a stochastic process which is known as Geometric Brownian Motion. Another two-echelon SC is proposed by Gomez_Padilla and Mishina (2009) in which an option contract is used to coordinate the SC in two following cases: single supplier-single retailer and multiple suppliers-single retailer. Their results demonstrate improvement in profit of the chain as well as that of both parties. A cooperative game theory approach to the option mechanism is addressed in Zhao et al., (2010) within which the retailer and the manufacturer adopt the order and the production quantity, simultaneously. They utilize a wholesale mechanism as a benchmark for the proposed contract to select the best parameters in order to coordinate the chain by a negotiation mechanism. They find out that a higher negotiation power and less risk-aversion resulted more profit for the corresponding party. Wang and Chen (2013) propose a Stackelberg game framework to model an option contract in cases of centralized and decentralized SCs. They demonstrate that the model has a unique solution and the SC could not be coordinated through the option contract. In another study, Zhao et al. (2013) introduce a bidirectional option contract as a risk hedging mechanism versus demand random fluctuations. They attain a closed-form solution for the initial order and order exercising quantities. Another recent study on option contract is performed by Chen et al. (2014), which considered the risk preferences of parties within the SC. They investigate the effects of risk preferences on the optimal order and production decisions. Supplier disruption is another type of uncertainty threatening the