



Optimal Buy-Back Price for Supply Chain Coordination

Tamás Faludi

University of Miskolc, Faculty of Economics, Institute of Management Sciences, Miskolc, Hungary

Abstract

Supply chain coordination is a very popular topic in the 21st century. Supply chains involve a large number of members, and in order to work together effectively, it is necessary to coordinate the value creation processes of these members in some way to ensure that the 'customer is king' principle is upheld and a high level of customer satisfaction is guaranteed. Because of the large number of members, chains are now considered as networks in the literature. Many opportunities are available to achieve the right level of coordination between members. One possible coordination tool is the contracts. This paper is focused on the chance of coordination improvement with the help of one interesting contract, which is the buy-back contract. This type of contract has a very sensitive point: the buy-back price. If this value is too low or too high, it results in negative influences on one or both parties. That is the reason why it is very important to determine an optimal buy-back price. The paper includes a model, which can help to understand the influencing factors of buy-back price, and with the help of this, an analytical model can be presented for the calculation of the optimal buy-back price.

Keywords: Supply Chain Management, Supply Chain Coordination, Contracts, Buy-Back Price

1. Introduction

Supply chain coordination is getting an important topic in the 21st century. Nowadays, supply chains are kind of networks (Long, 2016; Xue et al., 2022). Because of globalization, companies have no limits to establishing more subsidiaries and making more and more relationships all around the world. One reason for this is to reach better economical conditions or sell more products because of the more buyer in a foreign market (Demeter et al., 2006). The development of IT (which leads to the industry 4.0, and supply chain management 4.0) made it possible to maintain unhindered connections between countries and even continents (Szymczak, 2019; Shao et al., 2021).

One of the most important purposes of supply chain management is to coordinate the members' value-creating processes. If there are more and more members in the chain or the network, the coordination is getting to be more difficult. To implement the supply chain

concept and use the supply chain management, companies can be able to improve the coordination between them (Alicke & Iyer, 2013).

Supply chain coordination recommends many tools for coordination. This paper presents the contracts, especially the buy-back contract to help the coordination between partners. The purpose of the paper is to analyze the influencing factors of the buy-back price and create a model to define the optimal price.

2. Methodology

Primarily it will be presented a literature review on the possibilities and characteristics of coordination through contracts. Then, the buy-back contract will be described specifically and, based on the information collected, researcher build a model that describes the factors that influence the determination of the buy-back price, and use this to present a model that can be applied to determine the buy-back price.

2.1 Contracts in supply chain coordination

Contracts in the supply chain are kinds of a framework for appropriate cooperation. They define the cost-, profit-, and risk-sharing rates, and determine the responsibilities of parties. This will reduce conflicts of interest (Coltman et al., 2009; Stamatidou et al., 2019). Thus, contracts provide a solid basis for cooperation.

There are many types of contracts. Sluis and De Giovanni (2016) made an empirical analysis to compare the frequent types. There are many analytical types of research to define the conditions of contracts (Polo & Scarpa, 2013; Cai et al., 2020, Li et al., 2021; Vipin & Amit, 2021). These researches are making difference in the settings of the supply chains.

A centralized supply chain means that the partners would like to maximize the whole profit of the supply chain. To reach this goal, they cooperate and out their own profit-maximizing interests in the background. In a decentralized setting, members would like to maximize their own, individual profits. There is no really cooperation or alliances, at most a minimal cooperative relationship what they establish (Konur et al., 2016; Cai et al., 2020).

Researchers prove that a centralized setting is better. Because in the centralized setting, the supply chain can earn the maximum vertical integration, which is the purpose of the coordination. It means, that the value-creating processes are totally connected, the material- and the information flow are at the maximum level, so the partners' and customers' satisfaction is guaranteed. But then here is the question: why do not operate every chain in a centralized setting? There is a relatively simple answer: the conflict of interest. In the real business life, decentralized setting is more common. But even in a decentralized setting, it is important to keep the frames of the transaction, the relationship, even if it is a short-term. Contracts can deal with this problem. Because of the various types, companies can find the most suitable type for their attitudes and characteristics.

The paper is concentrated on one type of contract: the buy-back contract.

2.2 Characteristics of buy-back contract

This type of contract has a wide-range literature review. Many researchers analyze the coordination power of the buy-back contract and many of them compare the buy-back contract with other contract types (Table 1).

Table 1: Major results in terms of the buy-back contract

AUTHOR(S)	TOPIC	RESULTS
Zhao et al. (2014)	Fuzzy demand influenced buy-back contract	Under a medium level of demand uncertainties, the buy-back price needs to be adjusted for the changes in demand to help coordination
Sluis & De Giovanni (2016)	An empirical study of the contract types	A buy-back contract is preferred by the supply chain members
Tsao & Vu (2019)	Buy-back policies of power supply chain system	In a centralized setting, the buy-back policies can coordinate the chain
Doganoglu & Inceoglu (2020)	Buy-back contract between a dominating manufacturer and dominated retailer	Buy-back can improve the coordination in dual-channel and under demand certainties
Shi et al. (2020)	Supply chain finance system coordination with buy-back contract	The combination of buy-back contract and wholesale pricing improves the coordination
Vipin & Amit (2021)	Comparison of wholesale pricing and buy-back contract	In a retailer-dominated chain, wholesale pricing performances better
Li et al. (2022)	Comparison of contracts	Buy-back contract with the use of wholesale pricing in a centralized setting has a good coordination attitude

Source: own construction based on literature review

A short summary is given in Table 1. It is just a slice of the wide-range literature about the buy-back contract. These topics are mixed from various aspects of the coordination of buy-back contracts. There are many cases, where the buy-back contract is the base of some comparison – for example with the wholesale pricing contract or the revenue-sharing contract and some cases try to combine the different types of contract (Sluis & De Giovanni, 2016; Shi et al., 2020; Vipin & Amit, 2021; Li et al., 2022). Researches analyze the effects of demand disruptions and uncertainties for the use of buy-back contract (Zhao et al., 2014), and it can be also found in papers, which focus on the dominance and the supply chain settings and their impacts (Tsao & Vu, 2019; Doganoglu & Inceoglu, 2020; Li et al., 2022). The analysis of different aspects can give a total picture of the conditions, advantages, and disadvantages of using the buy-back contract.

If a simple supply chain is given, which consists of one supplier and one buyer, the logic of a buy-back contract means that the supplier buys the unsold items back from the buyer at a buy-back price. The purpose of the contract is to motivate the buyer to avoid shortages. According to the literature the supply chains like this – which includes only one buyer – can be coordinated with the help of the buy-back contract, and it can increase the total profit of the whole supply chain (Wu, 2013). The contract can decrease the risk of surpluses on the side of the buyer, but this will affect the supplier inventory politics negatively because with the buy-back there will be surpluses of the supplier's stock. This level of risk will increase in proportion to the number of customers.

Based on the conclusions of the literature, a buy-back contract may be suitable for coordinating the supply chain, if the chain has only a few – preferably one – buyers. Besides that, in the case of demand or supply uncertainties and disruptions, the coordination power of the contract is moderate. Thus, it is recommended to use only the chain, which has maximum medium-level disruptions (Hou et al., 2010).

In summary, the traditional buy-back contract means that the seller will buy the items or products not sold by the buyer back. For this, they arrange the buy-back price. The problem is derived from the amount of the price; sometimes this buy-back price is too much and makes the inequality in relationship. It expected a high level of risk-taking on the part of the partners, as the accumulation of stocks and the increase in prices caused by the buy-back price always generated an increase in costs, which not all companies are able and willing to accept. Determining the buy-back price if suppliers set high buy-back prices which will also affect the entire supply chain. This results in the disimprovement of the performance of partners, costs can be increased, performance can be decreased, and the profit can be lower than the expectations. And if it is lower than the expectations, the companies can become unprofitable. If these obstacles are eliminated, it will be able to coordinate the chain thanks to its positive effects. That is the reason why the buy-back price can be defined correctly, and all influencing factors must be taken into account.

2.3 Define the optimal buy-back price

If the buy-back price will be not optimal, it will affect many factors negatively, as the previous chapter was presented. Chapter 2 discussed the difference between centralized and decentralized settings. Centralized settings are preferred, but many chains operate as a decentralized chains. This paper will analyze the buy-back contract in a decentralized setting.

If the supply chain is decentralized, the ordered quantity will be less, because of the higher prices. Another problem the double marginalization, which means the different profit-maximization factors. Thus, members maximize their own profit and increase the marginal profit. It results in an increase in unit price as the product goes forward in the chain. A further consequence is the decreasing ordered quantity because of the increasing prices. But if a buy-back contract allows the risk-sharing of inventory, buyers will be motivated to order a higher quantity. It means the buy-back contract can increase the number of sales and with this, also can result in higher profits.

For this, let a simple supply chain model exist with one distributor and one retailer. The retailer directly sells the products in the market to the final customer.

First of all, it is needed to characterize the market with the linear demand function. It will help to calculate a market price because the reverse demand function will be shown in its calculation (Equation (1)).

$$\text{Market Price} = P_M = a - b \cdot q \quad (1)$$

Equation (1) includes the constants of the market (a ; b), and the ordered quantity (q). This will be the price, which will be purchased for the final customer or the next chain member.

The unit price will be calculated with the help of Equation (2).

$$\text{Unit Price} = P_U = \frac{a - c_R + c_D}{2} \quad (2)$$

Equation (2) includes one of the two market constants (a), and the members' flat costs (c_R ; c_D). The unit price is derived from the profit of the distributor. The price partial derivative form of the distributor's profit gives Equation (2).

The buy-back price is the next. The biggest problem is if the buy-back price is determined by one side, and devoid of any factors. To find the optimal level of buy-back price, let it be lower than the unit price. It is assumed, that members arrange the rate of revenue-sharing. α_D will be the revenue-sharing rate of the distributor, and α_R will be the retailer's revenue-sharing rate. The only profit factor of the retailer is the market price. The buy-back price should be influenced by this market price (Equation (3)).

$$\text{Buy-back Price} = P_{BB} = P_M \cdot (1 - \alpha_R) = \alpha_D \cdot P_M \quad (3)$$

Because the market price affects the purchase of the final customer, it will influence the ordered quantity. Thus, if the distributor's responsibility is to decrease the retailer's risk of surpluses, the buy-back price necessarily depends on the market price until the level of the revenue-sharing rate of the distributor. This logic leads to Equation (3).

Now, Equation (2) needs to change. Because the buy-back price will be not influenced by the market price. According to the rational behavior the distributor will build the rate of buy-back price into the unit price – it serves as a kind of guarantee in order to recover part of the buy-back price in the event of a possible buy-back. The corrected value of the market price is presented by Equation (4).

$$\text{Corrected value of market price} = P''_M = \alpha_R \cdot (c_D + c_R) + P_{BB} - c_R \quad (4)$$

With the help of the corrected value of the market price, the profit of individuals can be also calculated. The profits are influenced by the quantity-depend revenue and the rate of the value of each price relative to the buy-back price. Besides that, it needs to calculate the impact of flat costs.

$$\text{Profit of distributor} = \pi_D = (P_M \cdot q) \cdot \left(1 - \frac{P''_M}{P_U}\right) - (c_D \cdot q) \quad (5)$$

$$\text{Profit of retailer} = \pi_R = (P_M \cdot q) \cdot \left(1 - \frac{P''_M}{P_M}\right) - (c_R \cdot q) \quad (6)$$

Equation (5) shows the distributor's profit. The quantity-depend revenue, the rate of unit price and the corrected market price, and the quantity-depend flat cost of the distributor will give the profit.

Equation (6) shows the retailer's profit. The logic is the same, the equation includes the rate of market price and the corrected market price by the buy-back price, and also the quantity depends on flat cost.

3. Discussion and future research possibilities

A buy-back contract can be a good choice for companies with a bigger risk-taking attitude. The buy-back price itself is the biggest risk of this type of contract. As a cost or a probably profit-decreasing factor is the reason why companies avoid this contract. And yes, if the conditions are not appropriate, and the attitudes of all partners are not suitable for this contract, the coordination between the partners can be worse.

If the conditions are great to use this contract, it can improve the coordination between the partners. But this is not the only influencing factor. To make the application of this contract profitable and beneficial for each partner, the optimal buy-back price needs to be determined.

This paper presents one potentially good solution to determine the optimal buy-back price. For this, the paper assumes a simple supply chain in a decentralized setting, which means there is no serious cooperation between the members. The buy-back price will be not so high, if members realize, that the unit prices and the market prices are also influencing the value of the buy-back price. Besides that, it is recommended to arrange the rate of revenue-sharing, because with the help of this the optimal buy-back contract can be calculated easier and it will be fairer. One of the biggest problems with the buy-back price is too high. It will demotivate the seller to purchase a bigger quantity because if the buyer will be not able to sell all of them, she will need to buy them back at this higher price. This demotivation will decrease the efficiency of the individuals, and also the whole chain. That is the reason why it is needed to strive for the optimal buy-back price.

Paper presents a model, which uses the buy-back price influenced, corrected unit prices. It can be a guarantee for the seller for the compensation if she has to buy the unsold items back. This price is optimal because it also takes into account cost, unit prices, and market prices. Thus the value is lower than the original unit price. Based on this, the buyer is also worth buying at this price, and the seller is also in this position because the compensation is included in this buy-back price. As the new corrected price is lower than the simple unit price, it can be better to use than a wholesale pricing contract in a decentralized setting.

The model has limitations, such as it deals with only the decentralized setting. Another limitation is the revenue-sharing rates – the determination of them depends on many things. That is the reason why future research can be focused on the centralized settings, and what kind of differences will be between the use of buy-back contracts in centralized and decentralized settings. It can be worth to check the revenue-sharing rates. The revenue-sharing contract can be a good solution to make coordination better and reach the maximum vertical integration (Rhee et al., 2014; Pfeiffer, 2016; Yao et al., 2022). The model, presented in this paper has used wholesale pricing and the revenue-sharing contract, as well. Because the unit price in a decentralized setting is the same as in the decentralized wholesale pricing contract, and to reach the optimal buy-back price, the model has also used the revenue-sharing rates. In a deeper comparison of these contracts, focusing on the profits can give a greater picture of the conditions, advantages, and disadvantages of using contracts in terms of supply chain coordination.

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