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„Supply Chain Coordination with Contracts“

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1. Introduction

Why to coordinate a supply chain with contracts? What are supply chains and which importance they have in economic practice? Joseph J. Spengler (1950) was the first researcher who defined in his scientific paper “*Vertical integration and antitrust policy*” the term “*double marginalization*” and has got the ball rolling for further research.¹

Basically the main problem by which researchers are confronted is performance inefficiency resulting in ordering too little.² This inefficiency results from having at least two companies instead of having one company in a supply chain. In detail, we can distinguish between different companies being independent, acting alone and being responsible for their own mark-up. Hence, every involved company adds value to a product by producing, upgrading, transporting and selling. For example, a manufacturer produces a specific product and sells it to a retailer who resells it to end-consumer.

All companies involved in the supply chain maximize their profits. They are characterized by risk neutrality³. The retailer is confronted with stochastic demand meaning that he does not know how much the end-consumer will buy during the season. In the case of deterministic demand in which the retailer knows the number of sales in advance it is possible to decrease the double-marginalization effect to zero.⁴

The reason for having a problem with “double-marginalization” and consequently with supply chain inefficiency is due to the fact that the retailer orders too little as compared with an integrated supply chain. Hence, the optimal quantity in an integrated supply chain is the benchmark for the comparison of coordination mechanisms.

A lot has been done by researchers to solve the problem of “double marginalization” and its consequences to supply chain performance. Therefore, contractual agreements as coordination mechanisms were developed to improve the supply chain performance.

The paper of Lariviere and Porteus (2001) can be seen as a starting point for the research of supply chains with regards to efficiency. They have studied the consequences of a wholesale-price contract (also called the price-only contract) to total supply chain profits. Their results indicate that a price-only contract could never be a coordination mechanism in the sense that the retailer would order more. But they have also stated reasons in which a price-only contract

¹ See Spengler, J. (1950), pp. 347-352

² See Lariviere, M. A., Porteus, E. L. (2001), p. 293.

³ See Pasternack, B. A. (1985), p. 133.

⁴ For elimination of the „double marginalization effect“ see Kolay, S., Shaffer, G., Ordover, J. A. (2004), pp.431-437 in the case of complete information.

could be better off in contrast to other coordinating contracts in relation to specific demand properties.⁵

The researchers Cachon and Lariviere (2005) have examined the consequences of a specific marginal revenue curve to supply chain efficiency under a wholesale-price contract. They stated that under specific assumptions it is more difficult to implement a coordination mechanism because of the additional administrative burden it causes.⁶

The researchers have critically grappled with coordination mechanisms being already applied in economic practice.

The procedure of a revenue-sharing contract has been implemented by Blockbusters Inc. who was faced with customer dissatisfaction because of having too little videocassettes for rental in their stores.⁷ The buyback contract has already been applied by the journals- and magazines-industry under which the producers bought back unsold units at the end of the day or week.⁸ The sales-rebate contract under which the parties agree on price deductions on higher sales is used by HP through a specific reward program.⁹ And the quantity-flexibility contract is used by companies such as Microsystems, Nippon Otis, Solelectron, Toyota Motor Corporation and Compaq.¹⁰

All the above mentioned coordination mechanisms aim to achieve a better supply chain performance in the sense of giving an incentive to a retailer to order more. Consequently, the total supply chain profit increases and makes the supply chain more efficient.

Hence, this working paper deals with the question how it is possible to improve a supply chain in the matter of increasing the total supply chain profits and consequently to improve supply chain efficiency.

The working paper is structured as follows: In §§ 2-6 different coordination mechanisms will be discussed in reference to supply chain efficiency. Corresponding graphs shall show on one side the problems and on other side the solutions for the total supply chain. In § 2.1 the model, notations and assumptions for further research will be presented in more detail.¹¹

It will be shown that the contracts discussed in §§ 3-6 coordinate the supply chain: The retailer orders more and the total supply chain profit increases. Finally, in § 7 the main results will be summarized.

⁵ See Lariviere, M. A., Porteus, E. L. (2001), pp. 296-301.

⁶ See Cachon, G. P., Lariviere, M. A. (2005), pp. 38-40.

⁷ See Cachon, G. P., Lariviere, M. A. (2005), pp. 30-31.

⁸ See Pasternack, B. A (1985), pp. 133-140.

⁹ See <http://www.hpwards.co.uk>.

¹⁰ See Tsay, A. A. (1999), p. 1340.

¹¹ Based on Cachon, G. P. (2003), pp. 233-237.

2. The wholesale-price contract¹²

2.1 Introduction

The basis in studying supply chain coordination with contracts is the wholesale price contract. An intensive analysis in this respect was made by Lariviere and Porteus (2001).

The reason for operational research in this scientific area is the supply chain inefficiency resulting of the fact having two firms instead of having one firm. In other words, we have two profit realizations whereby in the first case the margin is lower than in the second case. The aim is to develop contracts as coordination instruments to increase efficiency in reference to the total supply chain performance.

Spengler (1950) called this fact as „double marginalization“¹³. He engaged in this area of research because of the fact that the Supreme Court of the United States saw it illegal to integrate one firm in another. They had the opinion that this strategy leads to reduced competition without consideration the differentiation and impact of horizontal and vertical integration.¹⁴

„Double marginalization“ can be illustrated by the case that the retailer takes too little on stock as in the case of an integrated channel. Therefore coordination mechanism such as the buy-back contract (Pasternack 1985), the revenue sharing contract (Cachon, Lariviere 2005), the quantity-flexibility contract (Tsay, Lovejoy 1999), and the sales rebate contract (Taylor 2002) were developed to receive a better supply chain performance. But these coordination mechanisms are linked with an administrative burden. Consequently we have first to investigate a price-only contract to make further research in relation to other contracts to determine in which extent the administrative expense is worth bearing.¹⁵

An example for an administrative burden could be in the sense of a collaborative relationship whereby the manufacturer has to monitor the sales of the retailer to assess the revenue for profit sharing. This example is important associated with a revenue sharing contract which we will discuss later.¹⁶

Now we have to define the model. The supply chain consists of two persons: the manufacturer producing the necessary quantity of a single product and sets the wholesale price and the sup-

¹² Based on Cachon, G. P. (2003).

¹³ See Lariviere, M. A., Porteus, E. L. (2001), p.293.

¹⁴ See Spengler (1950), p. 347.

¹⁵ See Lariviere, M. A., Porteus, E. L. (2001), p. 293.

¹⁶ See Cachon, G. P., Lariviere, M. A. (2005), p. 31.

plier, who orders a specific amount of goods from the manufacturer and sells it to the customer after random demand is realized. The following time line gives an overview on the interactions between the manufacturer and the retailer.¹⁷

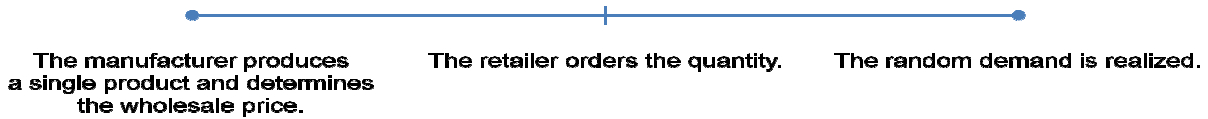


Figure 1¹⁸

As can be seen in figure 1 we have a time horizon of one. In reality it can be counted as one year. Further it is a classical newsvendor problem. The retailer orders a specific amount of the single product without knowing demand. After demand is realized the retailer is confronted with two situations, i.e. that either he has ordered too much or he has ordered too little of the single product.¹⁹

Additional another important question arise in this context. Because there are two parties involved in that process it has to be answered, how the resulting supply chain inefficiency can be defined and calculated. Therefore we have to consider of two scenarios: First we assume having one business, also called an integrated channel, where the manufacturer and the retailer operates under the same company name. It is regulated by transfer payments without a mark-up. Second we assume a situation as shown in figure 1.

If we compare the resulting profits in each situation to each other, we can say more about the supply chain efficiency. Hence, we have two different profits sizes to compare.

An important assumption in this model is that the manufacturer can be seen as a Stackelberg leader. He decides on the highness of the wholesale price and makes the first step in this strategic game.²⁰

A very interesting fact in relation to specific mathematical characteristic of the demand distribution is its impact to the supply chain efficiency and to the division of total profit between manufacturer and retailer. Lariviere and Porteus (2001) found out that the coefficient of variation (the division of the standard deviation by the mean from the demand distribution) play an important function for the total performance. In their research they call it "*relative variability*". As relative variability falls the manufacturer sets a higher wholesale price, which leads

¹⁷ See Lariviere, M. A., Porteus, E. L. (2001), p. 294.

¹⁸ See Cachon, G. P. (2003), p. 234.

¹⁹ See http://en.wikipedia.org/wiki/Newsvendor_problem.

²⁰ See Lariviere, M. A., Porteus, E. L. (2001), p. 294 and http://en.wikipedia.org/wiki/Stackelberg_leader.

into a better supply chain efficiency. Hence, he gets a larger portion of the supply chain profit.²¹

Therefore, it is possible that the supply chain with a price-only contract get better-off than with another coordination mechanism in connection with an additional administrative burden. Lariviere and Porteus (2001) proposed two possibilities, in which the manufacturer will set a smaller wholesale price. In the case of a fixed-price newsvendor (the retail price is exogenously) the manufacturer can increase the wholesale price without an impact on demand. Hence, in a situation where the retailer can be seen as price-setting newsvendor (the retail price is not exogenously and the retailer influences demand) the manufacturer would not increase the wholesale price. A higher wholesale price would imply a higher retail price. A higher retail price would imply less demand. Consequently the optimal quantity would not be achieved and there would not be an improvement of the supply chain performance.²²

The second possibility where the manufacturer is forced to set a low wholesale price is in the case of a “*more powerful retailer*”. The retailer has opportunity costs. He has alternative possibilities to make business. Therefore the manufacturer has to take into consideration his “*reservation utility*” as secondary condition to maximize his profit.²³

In the next subchapters we will discuss more about the wholesale-price contract, which is playing an important role for further study and being often watched in practice.

Therefore we begin by formulating our newsvendor-model in detail. Afterwards, we compare the result of an integrated supply chain (= single business) with the sum of the profits from the manufacturer and the retailer resulting in a supply chain (=no single business). Hence, when we can say more about supply chain inefficiency, it is possible to answer our question why the wholesale-price contract does not belong to the coordination mechanisms and ascertain the reasons why to develop supply-chain contracts.

2.2 The model²⁴

As mentioned above we have two persons in our supply chain: the manufacturer who produces the single product and the retailer who orders the single product to the manufacturer and sells it to the end-consumer. These persons are risk neutral and are maximizing their expected profit.²⁵

²¹ See Lariviere, M. A., Porteus, E. L. (2001), p. 294.

²² See Lariviere, M. A., Porteus, E. L. (2001), p. 301.

²³ See Lariviere, M. A., Porteus, E. L. (2001), p. 294 and p. 301.

²⁴ See Cachon, G. P. (2003), pp. 233-242.

²⁵ http://en.wikipedia.org/wiki/Risk_neutrality.

We face stochastic demand with a time horizon of one. The following sequence occurs: The manufacturer offers the retailer a wholesale-price contract, which he can accept or reject. In the case of agreement to the offered contract terms the retailer orders a specific amount of the single product and afterwards, demand happens.²⁶

For now we assume that the retailer has no opportunity costs and he is a fixed-price newsvendor, meaning he has no bargaining power.

A further important assumption is that the ordered quantity corresponds to the produced quantity due to the contractual enforcement. In this context it has to be mentioned that there are two different compliance regimes: “*voluntary compliance*” and “*forced compliance*” as studied by Cachon and Lariviere (2001). Under a compliance regime the manufacturer is responsible to have the ordered quantity of the single product on stock otherwise he has to take the legal consequences into account. Under voluntary compliance the ordered quantity is independent of legal consequences on stock.²⁷

In the next step we define the necessary variables:²⁸

r	Retail price
c_m	Production costs – manufacturer
c_r	Marginal costs - retailer
g_r	Goodwill costs - retailer
g_m	Goodwill costs - manufacturer
v	Salvage value
w	Wholesale price
$c = c_r + c_m$	Total costs of the supply chain
$g = g_r + g_m$	Total goodwill costs of the supply chain
$S(q) = q(1 - F(q)) + \int_0^q yf(y)dy$	
$S(q) = q - \int_0^q F(y)dy$	Expected sales
$I(q) = q - S(q)$	Expected leftover inventory
$L(q) = \mu - S(q)$	Expected lost sales

²⁶ See Cachon, G. P. (2003), p. 234.

²⁷ See Cachon, G. P., Lariviere, M. A. (2001), p. 630-631 and Cachon, G. P. (2003), p. 236.

²⁸ See Cachon, G. P. (2003), pp. 233-238.

The value of unsold goods is the salvage value at the end of the season. Goodwill costs occur in the situation of lost sales. Therefore, the retailers profit function is

$$\pi_r(q) = rS(q) - wq - c_r q - g_r L(q) + vI(q) \quad (1)^{29}$$

and the manufacturers profit function is

$$\pi_m(q) = wq - c_m q - g_m L(q) \quad (2)^{30}$$

The supply chains total profit can be determined as

$$\begin{aligned} \Pi(q) &= \pi_r + \pi_m = rS(q) - cq - gL(q) + vI(q) \quad (3)^{31} \\ &= (r - v + g)S(q) - (c - v)q - g\mu \end{aligned}$$

In the next subchapter we will discuss the supply chain performance and we will answer the question whether the wholesale-price as coordination mechanism is a coordinating contract or not?

2.3 Wholesale-price contract and its consequences to supply chain performance³²

In our game the manufacturer offers the retailer a contract being accepted by the retailer. The retailer knows now the offered wholesale-price and he maximizes his profit function. Hence, he differentiates his profit function (1) with respect to q and receives the following optimal quantity.

$$\begin{aligned} \frac{\partial \pi_r}{\partial q} &= \frac{\partial((r - v + g_r)S(q) - (c_r - v)q - g_r \mu - wq)}{\partial q} \\ &= (r - v + g_r)S'(q_r^*) - (w + c_r - v) \quad (3)^{33} \end{aligned}$$

²⁹ See Cachon, G.P. (2003), p. 236.

³⁰ See Cachon, G.P. (2003), p. 236.

³¹ See Cachon, G.P. (2003), p. 237.

³² See Cachon, G. P. (2003), pp .238-239.

By understanding the problem of supply chain inefficiency we have to differentiate the profit function of an integrated supply chain with respect to q to obtain the optimal order quantity.

$$\begin{aligned}\frac{\partial \Pi}{\partial q} &= \frac{\partial((r - v + g)S(q) - (c - v)q - g\mu)}{\partial q} \\ &= (r - v + g)S'(q^\circ) - (c - v)\end{aligned}$$

If we compare the optimal quantity q_r^* being chosen by the retailer in a supply chain with the optimal quantity q° in an integrated supply chain the following can be seen:

$$S(q^\circ)' = \frac{c - v}{r - v + g} \neq S(q_r^*)' = \frac{w + c_r - v}{r - v + g_r} \quad (4)^{34}.$$

These results illustrates that the wholesale-price is not a coordination mechanism in the sense of improvement of the supply chain performance.

The wholesale-price is not a coordinating contract but it is the basis for further study as mentioned above in the introduction.

In compliance with **(4)** the retailer does not order the optimal quantity q° .

Now the question arises at which wholesale-price the retailer orders the optimal quantity so that there is no supply chain inefficiency.³⁵

To answer this question we have to equate formula **(4)** and calculate the necessary wholesale price:

$$\frac{c - v}{r - v + g} = \frac{w + c_r - v}{r - v + g_r}$$

Further we assume the goodwill costs are 0 and we take the equation $c = c_r + c_m$ into account.

The wholesale-price has to be

³³ See Cachon, G. P. (2003), p. 238.

³⁴ See Cachon, G. P. (2003), p. 237.

³⁵ See Cachon, G. P. (2003), p. 238.

$$\begin{aligned}
w &= c - v - c_r + v \\
w &= c_r + c_m - v - c_r + v \quad (5)^{36} \\
w &= c_s
\end{aligned}$$

to get the optimal quantity q^o .

In other words, if the manufacturer equates the wholesale-price with his costs he would make no profit but the supply chain would be efficient in reference to the optimal order quantity. The retailer would order the quantity q^o if the $w = c_s$.

If the wholesale-price is greater than the supplier's costs we have the problem of “*double marginalization*” (Spengler 1950) resulting in the non-optimal order quantity.

To answer further questions regarding the supply chain performance we have to determine the supply chain efficiency in mathematical terms. As already mentioned in the introduction the development of coordinating contracts is the key to receive the optimal order quantity.

The supply chain efficiency can be calculated as follows:³⁷

$$\frac{\pi_r + \pi_m}{\Pi} = \text{the degree of supply chain performance. (6)}$$

The term $\pi_r + \pi_m$ is the sum of the profits in the sequential supply chain game with the non-optimal order chosen by the retailer.³⁸ The term Π is the total profit in an integrated supply chain, where the retailer and the manufacturer build one company without inefficiency. The wholesale-price contract would never achieve a supply chain efficiency of 1. Only in the case where the manufacturer makes no profit and sets the wholesale-price to his costs the supply chain would be efficient.

A very interesting fact in this context is the demand property of stochastic demand and their positive impact on supply chain efficiency without having a coordination mechanism. It could be the situation that a wholesale-price contract could be better in profit realization as other coordinating contracts having the goal to generate higher supply chain efficiency. Why? The reason is the administrative burden caused by the coordinating contracts. In some situations the supply chain would be better off having a wholesale-price contract as having a coordination contract with an administrative burden, which reduces the supply chain performance.³⁹

³⁶ For another mathematical illustration see Cachon, G. P., p. 238.

³⁷ See Cachon, G. P., p. 240.

³⁸ See Figure 1, p. 4.

³⁹ See Lariviere, M. A., Porteus, E. L. (2001), pp. 296-300.

In the next subchapters we will discuss the demand distribution property of a power function, the shape of a marginal revenue curve (convexity or concavity) and its consequences to the supply chain performance with a wholesale-price contract. Therefore, we will ascertain if in specific situations it would be better to have a price-only contract in contrast to other coordination mechanisms.

2.4 Demand distribution property of a power function and its consequences to supply chain performance.⁴⁰

The following example was taken from the working paper of Cachon (2003) and shall demonstrate the efficiency of the wholesale-price contract where demand follows a power function distribution.⁴¹

We formulate the following power function distribution $F(q)$ with its density function $f(q)$:

$$\begin{aligned} F(q) &= q^k \\ f(q) &= kq^{(k-1)} \quad .^{42} \\ \bar{F}(q) &= 1 - F(q) = S(q)' \end{aligned}$$

Expected sales are:

$$S(q) = q(1 - F(q)) + \int_0^q y(fy)dy .$$

The manufacturers profit function is:

$$\pi_m(q, w(q)) = w(q)q - c_m q - g_m(\mu - S(q)) .$$

The manufacturer determines $w(q)$ dependent on q_r^* and can be written as:

$$\begin{aligned} w(q) &= (r - v + g_r)\bar{F}(q) - (c_r - v) \quad .^{43} \\ \bar{F}(q) &= S(q_r^*)' = \frac{(w + c_r - v)}{(r - v + g_r)} . \end{aligned}$$

For further study we have to determine efficiency measures for the wholesale-price under consideration of the power function distribution:⁴⁴

⁴⁰ See Lariviere, M. A., Porteus, E. L. (2001), pp. 297-301.

⁴¹ See Cachon, G. P. (2003), pp. 240-241 and Lariviere, M. A., Porteus, E. L. (2001), pp. 298-299.

⁴² See Cachon, G. P. (2003), p. 240 and Bagnoli, M., Bergstrom, T. (1989), p. 10.

⁴³ See Cachon, G. P. (2003), p. 238.

⁴⁴ See Cachon, G. P. (2003), p. 240 and for further study Lariviere, M. A., Porteus, E. L. (2001), pp. 298-300.

$$\frac{\pi_m(q_m^*, w(q_m^*))}{\Pi(q_m^*)} = \frac{k+1}{k+2} = \text{the degree of the manufacturers profit share to the decentralized}$$

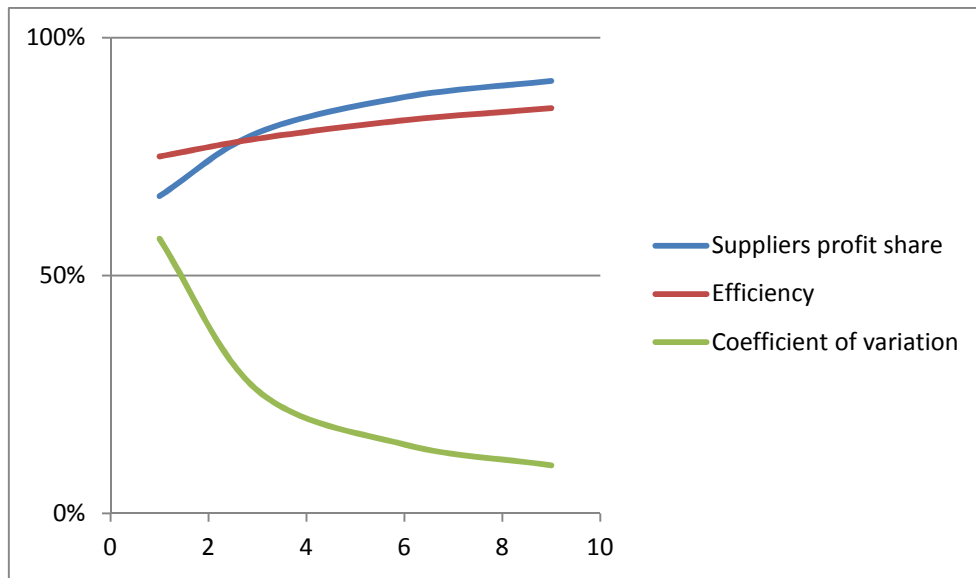
total supply chain profit and

$$\frac{\Pi(q_m^*)}{\Pi(q^0)} = \frac{k+2}{(k+1)^{1+\frac{1}{k}}} = \text{efficiency of the wholesale price contract.}$$

Hence, the manufacturer calculates the optimal quantity q_m^* to induce $w(q_m^*)$ from his profit function $\pi_m(q, w(q))$ by differentiating to q .

Assuming that $q \in (0,1)$ and $k > 0$ ⁴⁵ we are calculating the efficiency for the wholesale price contract (=total profit of the decentralized supply chain divided by the total profit of the integrated supply chain) and the profit share of the manufacturer.

The following graph shows these results:



Graph 1⁴⁶

As can be seen by Graph 1, the efficiency of the wholesale-price contract is increasing with increasing distribution parameter k and with decreasing “*relative variability*”⁴⁷. As relative variability falls the manufacturer gets the highest portion of the total decentralized supply chain profit.

In a situation with a high distribution parameter k it is more difficult to implement a coordination contract with consideration of the additional administrative burden.

⁴⁵ See Bagnoli, M., Bergstrom, T. (1989), p. 10.

⁴⁶ See Lariviere, M. A., Porteus, E. L. (2001), p. 299.

⁴⁷ See Lariviere, M. A., Porteus, E. L. (2001), p. 294. They define “*relative variability*” as the measure of the coefficient of variation (=standard deviation divided by the mean).

The rational explanation for the decreasing relative variability is the fact that the retailer has less demand risk. Hence, the manufacturer sets a higher wholesale-price and the compensation for the retailer is small. Assuming that the coefficient of variation would be 1 the supply chain efficiency would be 100% and the retailer would earn zero profit.

Hence, the gap between the decentralized and the integrated supply chain profit depends on the distribution parameter k . The smaller the more difficult it is to implement a coordination contract with respect to its administrative burden.

The next chapter gives an insight into the shape of a marginal revenue curve (convexity or concavity) and its consequences to the supply chain performance with a wholesale-price contract.⁴⁸ In our study we will observe that the shape of a marginal revenue curve plays also an important role for the supply chain performance. If the marginal revenue curve is concave then a positive influence on the degree of efficiency can be noted. Hence, it is more difficult to implement a coordination contract in reference to the administrative burden.

2.5 The shape of a marginal revenue curve and its consequences to the supply chain performance⁴⁹

We assume the following points:

- The goodwill costs and the salvage value are zero.
- The marginal revenue curve is $R(q)' = 1 - q^\theta$, where $\theta > 0$ and $q \in [0,1]$.⁵⁰
- A function in the form of $w(q) = R(q)'$ exists to induce the optimal order quantity⁵¹
- The supply chain inefficiency is expressed by λ .

The first order condition of the suppliers profit function can be determined as follows:

$$\begin{aligned}\pi_s &= q(w(q) - c) \\ \pi_s' &= R(q)' + qR(q)'' - c\end{aligned}\tag{52}$$

Because of the fact that the wholesale price is equal to the marginal revenue the optimal wholesale price can be determined as follows:

⁴⁸ See Cachon, G. P., Lariviere, M. A. (2005), p. 40.

⁴⁹ See Cachon, G. P., Lariviere, M. A. (2005), pp. 38-41.

⁵⁰ See Cachon, G. P., Lariviere, M. A. (2005), p. 39.

⁵¹ See Cachon, G. P., Lariviere, M. A. (2005), p. 38.

⁵² See Cachon, G. P., Lariviere, M. A. (2005), p. 38.

$$\begin{aligned}
0 &= R(q_s^*)' + q_s^* R(q_s^*)'' - c \\
R(q_s^*)' &= w(q_s^*) \\
w(q_s^*) &= c - q_s^* R(q_s^*)''
\end{aligned}
\tag{53}$$

For further study in reference to the supply chain efficiency we have to determine the optimal quantity both for the decentralized and centralized situation.

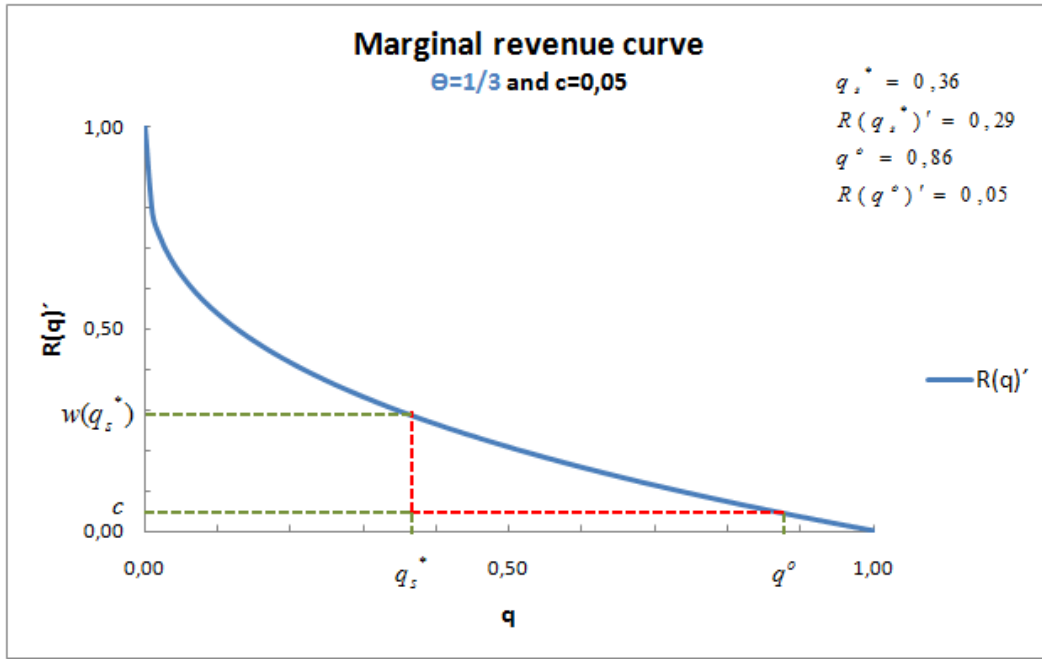
$$\begin{aligned}
0 &= R(q_s^*)' + q_s^* R(q_s^*)'' - c \\
0 &= (1 - q^\theta) + q(-\theta q^{\theta-1}) - c \\
0 &= 1 - q^\theta - \theta q^\theta - c \\
q^\theta + \theta q^\theta &= 1 - c \\
q^\theta &= \left(\frac{1 - c}{1 + \theta} \right) \\
q_s^* &= \left(\frac{1 - c}{1 + \theta} \right)^{\frac{1}{\theta}} < q^o = (1 - c)^{\frac{1}{\theta}}, \text{ as } R(q^o)' = c. \tag{54}
\end{aligned}$$

If we compare the two results it can be seen that the ordered quantity under a wholesale-price contract differs from the optimal quantity in an integrated supply chain. Hence, we are faced with the problem of supply chain inefficiency.

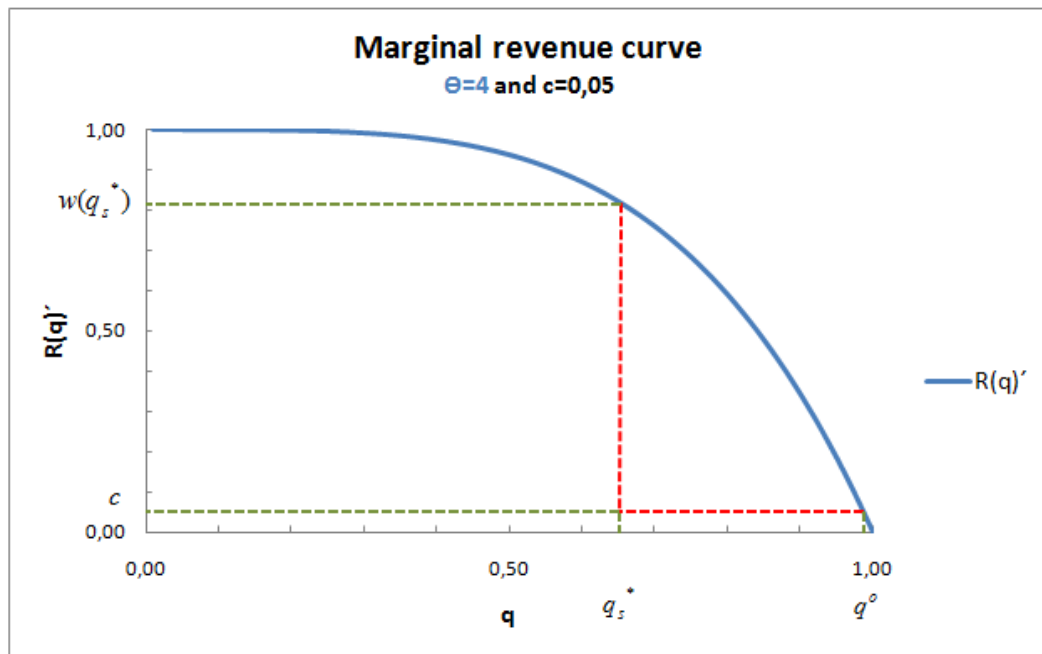
Cachon and Lariviere (2005) used the following graphs to show that the shape of a marginal revenue curve plays an important role in the improvement of the efficiency.

⁵³ See Cachon, G. P., Lariviere, M. A. (2005), p. 38.

⁵⁴ See Cachon, G. P., Lariviere, M. A. (2005), p. 39.



Graph 2⁵⁵



Graph 3⁵⁶

How it is possible to measure the supply chain inefficiency λ of the two cases? The area right and above the red dashed line can be seen as the inefficiency. It results from the non-optimal

⁵⁵ See Cachon, G. P., Lariviere, M. A. (2005), p. 39, whereby $\theta = \frac{1}{4}$.

⁵⁶ See Cachon, G. P., Lariviere, M. A. (2005), p. 39, whereby $\theta = 10$.

order quantity q_s^* . Hence, the amount of lost profit in the case of a decentralized system can be measured as follows:

$$\int_{q_s^*}^{q^0} (R(q)' - c) dq^{57}$$

Additional the following can be noted:

- If $\theta < 1$ the marginal revenue curve is convex,
- If $\theta = 1$ it is linear and
- if $\theta > 1$ it is concave.

For further understanding we add to our model two additional notations: $R(q)'_{convex}$ and $R(q)'_{concave}$.

Now it is possible to calculate the degree of inefficiency if $\theta > 1$:

$$\lambda_{concave} = \frac{\int_{q_s^*}^{q^0} (R(q)'_{concave} - c) dq}{\int_0^{q^0} (R(q)'_{concave} - c) dq}, \text{ and}$$

if $\theta < 1$:

$$\lambda_{convex} = \frac{\int_{q_s^*}^{q^0} (R(q)'_{convex} - c) dq}{\int_0^{q^0} (R(q)'_{convex} - c) dq}.$$

If we compare the two results we can note that $\lambda_{concave} < \lambda_{convex}$. With concavity of the marginal revenue curve the degree of inefficiency decreases. Hence, the supply chain is more efficient in the case of concavity. These results illustrates that if the marginal revenue curve is concave it is more difficult to implement a coordination mechanism with an administrative burden.

⁵⁷ See Cachon, G. P., Lariviere, M. A. (2005), p 39.

2.6 Summary

The outcome is that in specific situations the wholesale-price contract would be better off in contrast to coordinating contracts in relation to their administrative burden they cause. Explicitly, specific demand distribution properties or the shape of a marginal revenue curve complicates the implementation of coordination arrangements into a supply chain.

Further, we have ascertained that the wholesale-price contract cannot be seen as a coordination tool but its implications are important for further research.

The next chapter gives an insight into the first contract in which the manufacturer and the retailer shares the revenue to increase the supply chain quantity and consequently to increase efficiency.

3. The revenue-sharing contract

3.1 Introduction

In response to the supply chain inefficiency Cachon and Lariviere (2005) have examined the revenue sharing contract. It was already known and implemented by companies such as Blockbusters Inc.

Blockbuster Inc. is a company that offers the possibility to rent or buy cinema films. They are present around the world with over 2600 businesses engaged in the rental and selling of home entertainment.⁵⁸ Their success story has begun in 1998, where they have entered into a revenue-sharing contract with their suppliers. Before 1998 Blockbusters faced the problem of customer dissatisfaction. They had an insufficient quantity of video cassettes for rental in store because the purchase-price or wholesale-price was too high. As a consequence Blockbuster Inc. agreed to pay its suppliers between 30% and 45% of its profits. In return the suppliers have reduced the wholesale-price for a video tape from \$65 to \$8. Despite of the fact that Blockbuster has given a large share of its profits to suppliers their profits increased after 1998

⁵⁸ <http://www.blockbuster.com/corporate/internationalOperations>.

dramatically. Their market share increased from 25% to 31% and the cash-flow increased by 61%.⁵⁹

Hence, with a revenue-sharing contract it is possible to increase the ordered quantity and consequently the supply chain performance.

The question arises whether it is possible to implement this type of coordination mechanism in every industry or not? Cachon and Lariviere (2005) have identified three restrictions of implementing revenue-sharing contracts as coordination mechanism.⁶⁰

The first and most important restriction is the administrative burden. The supplier must have an insight to verify and control his share of profit, which is linked with effort and costs.

The second restriction would be in the case of retailer effort. The retailer enhances demand by investing in advertising and promotion. In this case the question arises, up to which extent the supplier bears the costs. This situation would lead in a higher administrative burden and the coordination contract would not be better off compared to the classical wholesale-price contract. And third, in a price-setting newsvendor model (the retail price is not stated exogenously) with quantity competing retailers (also known as “*Cournot competition*”⁶¹) in the form of an oligopoly the revenue-sharing contract doesn’t work. The retailer is faced with the profit function contingent on price, quantity and the profits of the other retailers. Hence, the revenue-sharing contract does not work in an oligopoly.⁶² Only in the case of perfect competition the revenue-sharing contract can be used as coordination mechanism.⁶³

In the next section we get to the bottom of the question how the revenue-sharing contract works and how it is possible to increase the overall supply chain performance? And how much the retailer orders if he is confronted with additional effort costs? For example: He invests in promotion and advertising to enhance consumer demand. Therefore, is it possible to generate the optimal order quantity as in the case of an integrated supply chain? If yes, which value the corresponding contractual parameters would have? Therefore we are first defining the model.

⁵⁹ See Cachon, G. P., Lariviere, M. A. (2005), p. 30 and <http://knowledge.wharton.upenn.edu/article.cfm?articleid=258>.

⁶⁰ See Cachon, G. P., Lariviere, M. A. (2005), p. 31.

⁶¹ http://en.wikipedia.org/wiki/Cournot_competition.

⁶² See Cachon, G. P., Lariviere, M. A. (2005), pp.36-38.

⁶³ See Dana, J. D., Spier, K. E. (2001).

3.2 The model⁶⁴

For further study we take the notation and variables as determined in the previous model. We augment our model by the variable $(1 - \phi)$ being the portion of revenue the retailer has to pay to the manufacturer. Hence, $\phi \in [0, 1]$ is the portion of revenue the retailer keeps for himself. We assume the same timeline for the interactions between the manufacturer and the retailer as defined in figure 1. The retailers profit function resulting from the additional contractual agreement in reference to ϕ can be determined from the formula defined in **(1)**:

$$\begin{aligned}\pi_r(q, w) &= rS(q) - wq - c_r q - g_r L(q) + vI(q) \\ \pi_r(q, w) &= rS(q) - wq - c_r q - g_r (\mu - S(q)) + v(q - S(q)) \\ \pi_r(q, w) &= ((r - v) + g_r)S(q) - (w + c_r - v)q - g_r \mu\end{aligned}$$

We define the term $(r - v)S(q)$ as the revenue dependent on quantity and retail price and receive the following profit function:

$$\begin{aligned}\pi_r(q, w, \phi) &= (\phi(r - v) + g_r)S(q) - (w + c_r - \phi v)q - g_r \mu \\ \pi_r(q, w, \phi) &= \phi R(q, r) - (w + c_r - \phi v)q - g_r (\mu - S(q))\end{aligned}\quad (7)^{65}$$

The manufacturers profit function can be determined in the same way and can be defined as follows:

$$\begin{aligned}\pi_m(q, w, \phi) &= ((1 - \phi)(r - v)S(q)) - (c_m - w - (1 - \phi)v)q - g_m (\mu - S(q)) \\ \pi_m(q, w, \phi) &= (1 - \phi)R(q, r) - (c_m - w - (1 - \phi)v)q - g_m (\mu - S(q))\end{aligned}\quad (8)^{66}$$

If $\phi = 1$ the profit functions **(7)** and **(8)** correspond to a normal wholesale-price contract. The term vq has to be seen as part of the revenue. Hence, the retailer has the contractual obligation to pay the manufacturer $(1 - \phi)vq$.

In the next subchapter we are discussing the results from a revenue-sharing contract and its impact on supply chain performance.

⁶⁴ See Cachon, G. P. (2003), pp. 246-247 and Cachon, G. P., Lariviere, M. A. (2005), p. 32.

⁶⁵ See Cachon, G.P. (2003), p. 246.

⁶⁶ See Cachon, G.P. (2003), p. 246.

3.3 Revenue-sharing contract and its consequences to supply chain performance⁶⁷

What is the optimal wholesale-price in a revenue-sharing contract to receive the optimal quantity (q_0) like in an integrated supply chain?

We know from the wholesale-price contract that the manufacturer has to set the wholesale-price to his costs ($w = c_m$) to receive the optimal order quantity. But in this situation he would make no profit.

To answer the question we have to differentiate formula (7) with respect to q :

$$\frac{\partial \pi_r(q, w, \phi)}{\partial q} = (\phi(r - v) + g_r)S(q^*)' - (w + c_r - \phi v)$$

From the above differentiation we can determine the quantity chosen by the retailer under a revenue-sharing contract:

$$S(q^*)' = \frac{w + c_r - \phi v}{\phi(r - v) + g_r}. \quad (9)$$

If we assume for clearer understanding that the goodwill costs and the salvage value are zero and compare the results to that of a wholesale-price contract the following can be stated:

$$S(q^*)' = \frac{w + c_r}{\phi r} > S(q_r^*)' = \frac{w + c_r}{r}.$$

Hence, the retailer orders under a revenue-sharing contract more as in the case of a price-only contract. Therefore, the revenue-sharing contract increases the efficiency of the supply chain and consequently the total supply chain performance.

For further calculating we assume that the goodwill costs are zero and the total costs are $(c_r + c_m)$. In the next step the optimal quantity calculated from an integrated channel ($S(q^o)'$) set to be equal to $S(q^*)'$:

⁶⁷ For detail mathematical analysis see Cachon, G. P. (2003), pp. 246-248 and Cachon, G. P., Lariviere, M. A. (2005), pp. 32-36

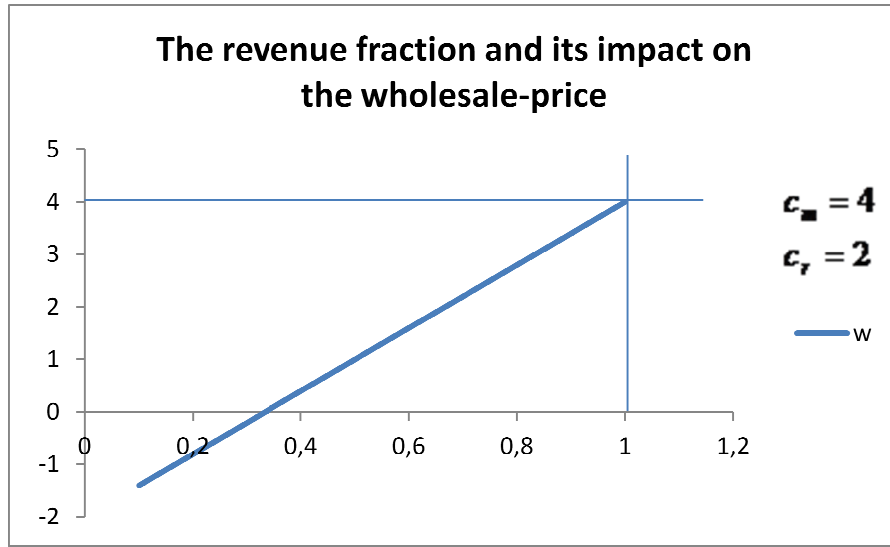
$$\frac{c-v}{r-v+g} = \frac{w+c_r-\phi v}{\phi(r-v)+g_r}$$

$$w = (c-v)\phi - c_r + \phi v$$

$$w = \phi c - c_r \quad (10).^{68}$$

To obtain the optimal quantity (q_0) the manufacturer has to set his wholesale-price equal to the formula (10).

For further understanding the following graph shows that the manufacturer has to set his wholesale-price below his costs to achieve coordination.



Graph 4

The wholesale-price would be negative when $\phi < \frac{c_r}{c}$ ⁶⁹ and would be in the situation in which the manufacturer has to pay for making business with the retailer.

This result also shows that the manufacturer has to set his wholesale-price under his costs to achieve coordination. Hence, the manufacturer sells the ordered quantity at a loss but he is entitled to get his fraction from the revenue made by the retailer.⁷⁰

As can be seen by formula (9) the revenue-sharing contract is closer to the optimal order quantity expressed in the formula (4).

⁶⁸ See Cachon, G. P., Lariviere, M. A. (2005), p. 33.

⁶⁹ See Cachon, G. P., Lariviere, M. A. (2005), p. 33.

⁷⁰ See Cachon, G. P., Lariviere, M. A. (2005), p. 42.

3.4 Effort costs and their consequences to revenue-sharing⁷¹

Promotion, advertising, price discounts, samples and vouchers are connected with additional costs ($c(e)$) but they enhance consumer demand.⁷² It would be unfair if the retailer would have to bear all the costs. In that case the retailers total costs increase and his profit share decreases. Whereby the manufacturers profit share remains unaffected negatively. He will profit from such a case. Thus, in respect to fairness an additional contractual agreement would be necessary but that would be linked with additional administrative expenses. And, how much of the sales can be allocated to the effort costs.

For now, by the additional effort costs demand and revenue increases and the manufacturer gets more without a contribution to effort costs and the question arises under which conditions the retailer orders optimal. Therefore, we have to consider the integrated profit function and the retailers profit function to say more.

The integrated profit function dependent on the quantity and the effort level differentiated with respect to e is:

$$\frac{\partial \Pi(q, e)}{\partial e} = \frac{\partial R(q, e)'}{\partial e} - c(e)' = 0^{73} \text{ and}$$

the profit of the retailer differentiated with respect to e is:

$$\frac{\partial \pi_r(q, e)}{\partial e} = \phi \frac{\partial R(q, e)'}{\partial e} - c(e)' = 0^{74}.$$

The retailer would only order optimal if $\phi = 1$. In this case the manufacturer would earn nothing because he would have to equate the wholesale-price with his costs ($w = c_m$) to induce the optimal order quantity.

Voluntary contribution and transparency would solve the problem. The manufacturer shares the effort costs with the retailer, which is called “*effort sharing*”.⁷⁵ Cost sharing is possible if effort costs and demand are determinable, whereby demand further has to be observable.⁷⁶

⁷¹ See Cachon, G. P., Lariviere, M. A. (2005), p. 41.

⁷² See Krishnan, H., Kapuscinski, R., Butz, D. A. (2004), p. 51.

⁷³ See Cachon, G. P., Lariviere, M. A. (2005), p. 41.

⁷⁴ See Cachon, G. P., Lariviere, M. A. (2005), p. 41.

⁷⁵ See Krishnan, H., Kapuscinski, R., Butz, D. A. (2004), p. 56.

3.5 Summary

Revenue-sharing increases the order quantity and induces a better supply chain performance. Therefore, the manufacturer has to set his price below his costs to achieve coordination. Effort costs which are spent to increase consumer demand needs to be fairly shared so that nobody in the supply chain gets worse off.

⁷⁶ See Krishnan, H., Kapuscinski, R., Butz, D. A. (2004), p. 55.

4. The buyback contract⁷⁷

In the following chapter we will discuss the buyback contract and their consequences to the supply chain performance. We will assess that this type of contract can be seen as a coordination mechanism and we will see that a buyback contract does not differ from a revenue-sharing contract in the fixed-price newsvendor model under certain assumptions.

4.1 Introduction

This form of contract is often observed in business. The publishers of journals, magazines and periodicals offer the contractual agreed possibility to buy back the unsold goods one day, week or month later. By such a contractual agreement the supplier has the intention to increase the ordered quantity to the optimal order quantity. This procedure reduces the retailer's risk of making a loss if he orders too much.

In specific contractual agreements the supplier and the retailer bears the risk of unsold goods, which leads to a better supply chain performance. In the study of Pasternack (1985) three different contractual agreements are presented to coordinate the supply chain, whereby one of them induces the optimal order quantity both in the single-retailer environment and in the multi-retailer environment.⁷⁸

The first contractual agreement contains the clause that the manufacturer is obligated to buy back all unsold goods at full value. This clause leads to a full shift of risk to the supplier or manufacturer, whereas the retailer has no risk. Consequently he would order suboptimal. The second contractual agreement allows the retailer to return a percentage of bought goods at full value. To receive system optimality it can be adapted to a single-retailer environment but not to a multi-retailer environment. In the third contractual agreement the retailer has the possibility to return all unsold goods at partial value. This arrangement can be adapted to the single and multi-retailer environment.⁷⁹

A further interesting fact is the similarity of the buyback contract to the revenue-sharing contract in the fixed-price newsvendor model. In a fixed-price market with a buyback agreement it is possible to calculate contractual terms, which are inducing the same solution as in the

⁷⁷ In the style of Cachon, G. P. (2003), pp. 242-246 and Pasternack, B. A. (1985), pp. 133-140.

⁷⁸ See Pasternack, B. A. (1985), p. 135.

⁷⁹ See Pasternack, B. A. (1985), pp. 135-137.

case of a revenue-sharing contract.⁸⁰ In contrast with a price-setting market, coordination is only achieved by the fact that the supplier or manufacturer makes no profit.⁸¹

A buy-back contract could also cause an administrative burden. An example could be if the manufacturer has to check and monitor the leftover inventory which would imply higher costs. Hence, the additional costs reduce the total supply chain performance.⁸² As a consequence it could be difficult in certain circumstances to implement a buy-back contract where the gap between the additional profits is closer to the administrative burden. In such a case it could be better to have a price-only contract.

After having introduced some basic concepts concerning the buyback contract we consequently define the model for a buy-back contract. Then we calculate the order quantity under the different contractual agreements to have a deeper insight into the supply chain performance. We will assess that there are four different possibilities to design a buy-back contract, whereby three of them can be used for supply chain coordination.

Finally, we calculate the contractual terms, which are inducing the same profit realization as under the revenue-sharing contract in the fixed-price newsvendor model. In other words, we are looking for the contractual parameters of a buy-back contract which are inducing the same result as in the case of revenue-sharing.

4.2 The model

We assume a fixed-price newsvendor model in a single-retailer environment with stochastic demand. The interactions as mentioned in figure 1 takes place. We extend our model by the term R . R stands for the percentage of leftover inventory which can be returned by the retailer after the season. The retailer receives the value b per unit returned.⁸³

We distinguish between 5 scenarios or contractual agreements to analyze supply chain performance:⁸⁴

1. no buy-back ($R = 0$ and $b = 0$),
2. total buy-back at full value ($R = 1$ and $b = w$),
3. total buy-back at partial value ($R = 1$ and $v < b < w$),

⁸⁰ See Cachon, G. P., Lariviere, M. A. (2005), pp. 33-34.

⁸¹ See Cachon, G. P., Lariviere, M. A. (2005), p. 34.

⁸² See Cachon, G. P. (2003), pp. 242-243.

⁸³ See Pasternack, B. A. (1985), p. 135 and Cachon, G. P. (2003), p. 242.

⁸⁴ See Pasternack, B. A. (1985), pp.133-135.

4. partial buy-back at full value ($R = [0,1]$ and $b = w$) and
5. partial buy-back at partial value ($R = [0,1]$ and $v < b < w$).

The solution of the first contractual agreement would be the same as in the case of a whole-sale-price contract.

In the second scenario, where the manufacturer buys all goods of leftover inventory from the retailer at full value cannot be considered as optimal.⁸⁵ In this case the manufacturer would bear all the risk of unsold goods. The retailer would not have the incentive to order optimal. Demand forecast costs money and so he would order more rather than having too less on stock.⁸⁶

The third, fourth and fifth policy can be seen as optimal for further calculation. Therefore, we will discuss in the next chapter the third, fourth and fifth policy in detail.

4.3 Buyback contract and its consequences to supply chain performance⁸⁷

We do not assume the situation where the goodwill costs are zero. As can be shown by the interactions (Figure 1) the manufacturer and the retailer do not know consumer demand in advance. And so the manufacturer has to take into account for further calculation also the situation that there are expected lost sales. We also do not assume that the salvage value is zero. The retailers profit with a buy-back agreement in general can be shown as follows:

$$\pi_r(q) = rS(q) - wq - c_r q - g_r L(q) + bR(q - S(q)) + v(1 - R)(q - S(q)).$$

$$\pi_r(q) = rS(q) - wq - c_r q - g_r L(q) + (q - S(q))(bR + v(1 - R))$$

Now we investigate the third contractual agreement where the manufacturer buys the remaining of ordered quantity back at partial value. In this situation $R = 1$ and $v < b < w$. Hence, the retailer is faced with the following profit function:

⁸⁵ See Pasternack, B. A. (1985), p. 137.

⁸⁶ „For example, as reported in the February 18, 1982 issue of the Wall Street Journal, record manufacturers had been allowing full credit for all unsold goods records by retailers. The article went on to report that recent policy changes by a number of manufacturers have limited the amount of returns for full credit to around 20%” (Pasternack, B. A. 1985, p. 134).

⁸⁷ For detail mathematical calculation see Pasternack, B. A. (1985), pp. 133-140 and Cachon, G. P. (2003), pp. 242-246.

$$\pi_r(q)_{buyback^3} = rS(q) - wq - c_r q - g_r L(q) + b(q - S(q))$$

We now differentiate the above profit function to q and receive:

$$S(q_r^*)'_{buyback^3} = \frac{w + c_r - b}{r - b + g_r} \quad (11)^{88}$$

It can be proven that the above formula is closer to $S(q^0)'$ as formula (4) being the solution in the case of price-only contract. Hence, we can assess the following solution with respect to $S(q^*)'$:

$$S(q^*)'_{integrated} < S(q_r^*)'_{buyback^3} < S(q_r^*)'_{wholesale-price}.$$

$$\text{Order quantity from } S(q_r^*)'_{buyback^3} = \frac{w + c_r - b}{r - b + g_r} > \text{as the order quantity from}$$

$$S(q_r^*)' = \frac{w + c_r - v}{r - v + g_r}.^{89}$$

Hence, it is possible to induce a better supply chain performance with the buyback contract under the third contractual agreement because $b > v$.

Now, we look at the fourth contractual agreement where the manufacturer buys at full value a portion of unsold goods back. The retailers profit function in this case is:

$$\pi_r(q)_{buyback^4} = rS(q) - wq - c_r q - g_r L(q) + wR(q - S(q)) + v(1 - R)(q - S(q)).$$

The manufacturer buys the portion of unsold goods at the wholesale-price back and the retailer sells the remainder at the salvage value. The first derivative of the retailers profit function with respect to q is:

$$S(q_r^*)'_{buyback^4} = \frac{c_r + w(1 - R) - v(1 - R)}{r + g_r - wR - v(1 - R)}. \quad (12)^{90}$$

⁸⁸ For detail mathematical analysis see Pasternack, B. A. (1985), pp. 135-138.

⁸⁹ Supply chain efficiency increases, see graph 6, p. 31.

Proof: We assume that $R = 0$. Hence, $S(q_r^*)'_{buyback^4} = \frac{c_r + w - v}{r + g_r - v}$ induces the solution under a wholesale-price contract.

Finally, the retailers profit under the fifth contractual agreement would be

$$\pi_r(q)_{buyback^5} = rS(q) - wq - c_r q - g_r L(q) + bR(q - S(q)) + v(1 - R)(q - S(q))$$

and the first derivative with respect to q is

$$S(q_r^*)'_{buyback^5} = \frac{w + c_r - bR - v(1 - R)}{r + g_r - bR - v(1 - R)}. \quad (13)^{91}$$

Proof: We assume that $R = 0$ and $b = v$. Therefore, $S(q_r^*)'_{buyback^5} = \frac{w + c_r - v}{r + g_r - v}$. The same solution as in the case of a price-only contract would be induced.

In the next subchapter we will analyze the solutions based on a graphical illustration. We will compare the first derivative of the expected sales of the wholesale-price contract with that of the different contractual agreements under a buyback contract. We will assess that a buyback buy-back contract induces a better performance as in the case of a price-only contract.

4.4 Graphical illustration of the three contractual agreements⁹²

We assume the following information's:

Retail price.....	12
Retailer's costs.....	5
Retailer's goodwill costs.....	2
Salvage value.....	2
Wholesale-price.....	5
Manufacturer's costs.....	3

⁹⁰ For detail mathematical analysis see Pasternack, B. A. (1985), p. 136.

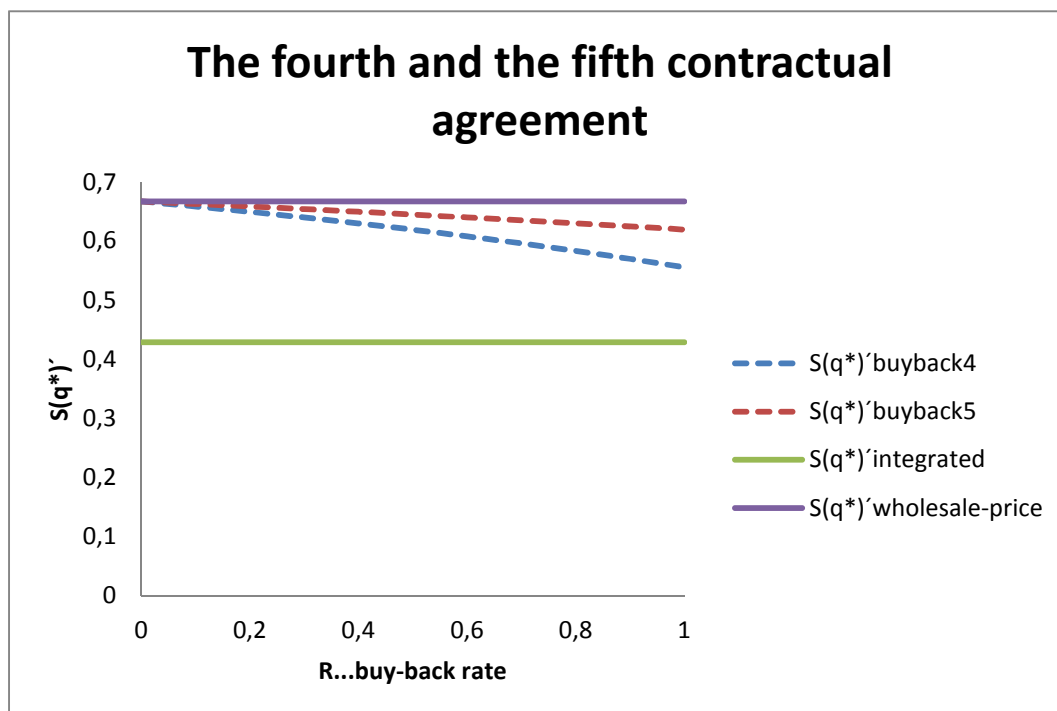
⁹¹ For detail mathematical analysis see Pasternack, B. A. (1985), p.136.

⁹² Regarding to the illustration of the five contractual agreements see Pasternack, B. A. (1985), p. 138.

Manufacturer's goodwill costs.....	2
Buy-back value.....	3.5

The retailers and the manufacturer's goodwill costs are calculated by lost profits. We assume that the buyback value is the mean of the salvage value and the wholesale-price (for the third and fifth contractual agreement) and plays an important role in calculating the solution for the fifth contractual agreement.

The first graph shows the derived expected sales as a function of the buy-back rate.



Graph 5

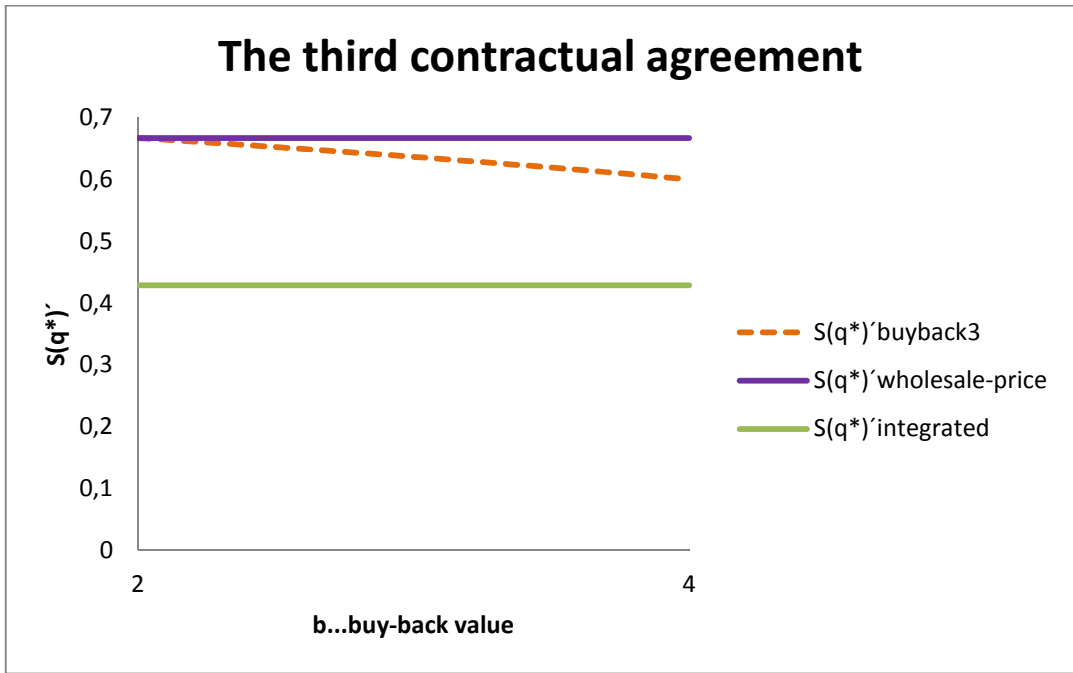
Graph 5 indicates that the two contractual agreements improve the performance of the total supply chain. The higher the buyback rate the closer is the supply chain performance to that of an integrated supply chain. With this contractual agreement it is possible to augment the order quantity but it is not possible to induce the integrated supply chain quantity.

The fourth contractual agreement induces a better performance than the fifth contractual agreement as long as the buyback value is between the salvage value and the wholesale-price ($v < b < w$). On condition that $b = w$ the following result would be induced:

$$S(q_r^*)'_{buyback^5} = S(q_r^*)'_{buyback^4}.$$

Hence, the buy-back contract with these two contractual agreements can be seen as a coordination mechanism.

The second graph shows the solution of the third contractual agreement.



Graph 6

Graph 6 indicates also an improvement of the performance. Hence, the third contractual agreement can also be seen as a coordination mechanism.

If we compare the two graphs with each other we recognize that the best performance is induced by the fourth contractual agreement, which corresponds with economic practice (reported in the Wall Street Journal, February 18, 1982: “*Record manufacturers had been allowing full credit for all unsold records by retailers. The article went on to report that recent policy changes by a number of manufacturers have limited the amount of returns for full credit to around 20%*”⁹³).

In the next chapter we will see that the buy-back contract is similar to the revenue-sharing contract under certain assumptions. Therefore, we will calculate the contractual terms of a buy-back contract inducing the same optimal solution. We are looking for $[b, w_b]$ corresponding to $[\phi, w_r]$.

⁹³ See Pasternack, B. A. (1985), p. 134.

4.5 The similarity of the third contractual agreement to a revenue-sharing contract⁹⁴

As we have defined the same assumptions for the two coordination mechanisms it is possible to confront the retailers profit functions with each other. By way of illustration we compare the retailers profit function with the third contractual agreement with the retailers profit function under the revenue sharing-contract.

$$\begin{aligned}\pi_r^{buyback3} &= S(q)((r - b) + g_r) - q(w_b + c_r - b) - g_r\mu \\ \pi_r^{revenue-sharing} &= S(q)(\phi(r - v) + g_r) - q(w_r + c_r - \phi v) - g_r\mu\end{aligned}$$

From the above profit functions we calculate $[b, w_b]$ by equation and substitute w_r by $\phi c - c_r$ ⁹⁵ and receive the buy-back rate and the wholesale-price, which are inducing the same profit realizations as in the case of a revenue-sharing contract:

$$\begin{aligned}r - b + g_r &= \phi(r - v) + g_r \\ b &= r - \phi(r - v)\end{aligned}\quad 96$$

$$\begin{aligned}w_b + c_r - b &= w_r + c_r - \phi v \\ w_b &= \phi(c - v) - c_r + b\end{aligned}\quad 97$$

The buy-back rate is dependent on the retail price. Hence, this model works only with a fixed-price newsvendor.⁹⁸

The calculation of the contractual parameters in a price-setting newsvendor model would only be possible if the manufacturer publishes the above contractual terms. Whereby the buy-back rate and the wholesale-price must be dependent on the retail price:⁹⁹

$$\begin{aligned}b(r) &= r - \phi(r - v) \\ w_b(r) &= \phi(c - v) - c_r + b.\end{aligned}$$

⁹⁴ For detail mathematical analysis see Cachon, G. P., Lariviere, M. A. (2005), pp. 33-34.

⁹⁵ See formula 10, p. 20.

⁹⁶ Compare with Cachon, G. P., Lariviere, M. A. (2005), p. 33 for another result.

⁹⁷ Compare with Cachon, G. P., Lariviere, M. A. (2005), p. 34 for another result.

⁹⁸ See Cachon, G. P., Lariviere, M. A. (2005), p. 33.

⁹⁹ For details see Cachon, G. P., Lariviere, M. A (2005), p. 34.

4.6 Summary

We have ascertained that it is possible to induce the same supply chain performance as in the case of a revenue-sharing contract. Further, we have stated that the fourth contractual agreement has the best performance by contrast with the two others. The graphical illustration corresponds to the economic practice as published by the Wall Street Journal.

The buy-back contract can be used to induce a better performance. Hence, a buy-back contract coordinates a supply chain.

5. The sales-rebate contract¹⁰⁰

5.1 Introduction

The idea behind the sales-rebate contract is that the manufacturer gives the retailer an incentive to order more. The consequences should be clear. The retailer orders more and the total supply chain profits should increase.

We can distinguish between two contract forms: A “*linear-rebate*” contract, in which the manufacturer is obligated to give a price deduction on every unit sold to end consumer and a “*target-rebate*” contract, in which the manufacturer is obligated to give a price deduction only after a specific amount of goods were sold.¹⁰¹ In the latter case the bilateral agreement involves a threshold and a discount rate.

Hewlett Packard (HP) has introduced a reward system for resellers. A registered company gets between 1% and 5% in cash of their sales back, which is credited on its account. The credited money can be spent again in further HP products.¹⁰²

In 2008 HP has established the “gold-partnership” program. The “gold-partners” work closely with HP. They have stood out from other companies by strict compliance of HP guidelines

¹⁰⁰ In the style of Taylor, T. A. (2002), p. 992-1007 and Cachon, G. P. (2003), pp. 252-254.

¹⁰¹ See Taylor, T. A. (2002), p. 992.

¹⁰² See <http://www.hprewards.co.uk/>.

and trainings.¹⁰³ For the gold-partners HP has developed a mixed reward system consisting of a linear and target-rebate scheme.¹⁰⁴

In the United States over 400 million rebate schemes are offered with a total volume of \$6 billion every year.¹⁰⁵ Cho, McCardle and Tang (2009) have brought up an interesting question in this context. Why companies do not launch short price reductions instead of rebate programs? In their scientific paper they advanced two interesting arguments:¹⁰⁶

1. In the case of a price reduction consumers often apply a “wait and see” strategy. As a result turnover is lost temporarily.
2. Rebate schemes can be more profitable in the sense that consumers often forget to claim rebates. According to Cho, McCardle and Tang (2009) 40% of total granted rebates are un-cashed.

In their paper they also brought two negative effects of rebate schemes in:¹⁰⁷

1. Temporary price reductions seem more attractive as rebate schemes. The reason lay in the fact that for consumers it is more stressful to redeem a rebate as compared with a price-reduction.
2. Companies have to advertise and promote their rebate policy, which is connected with additional costs.

In our case rebates and price reductions cannot be compared with each other because rebates are cashed only in the case of sales realization.¹⁰⁸

Also in the case of time horizons in which channel rebates are granted has to be differentiated. Channel rebates can be granted without a time limitation as in the example of HP or with a time restriction. In our model the time restrictions does not play an important role because we have assumed a one-period model.¹⁰⁹

¹⁰³ See http://h41320.www4.hp.com/cda/mwec/display/main/hppp_content.jsp?zn=hpsmb&cp=1931-9129-9196_4063_5.

¹⁰⁴ <http://www.channelweb.co.uk/crn-uk/news/2029462/hp-losers-pfr-changes>.

¹⁰⁵ See Cho, S., McCardle, K. F., Tang, C. S. (2009), p. 426.

¹⁰⁶ See Cho, S., McCardle, K. F., Tang, C. S. (2009), p. 426.

¹⁰⁷ See Cho, S., McCardle, K. F., Tang, C. S. (2009), p. 427.

¹⁰⁸ See Taylor, T. A. (2002), p. 993.

¹⁰⁹ See Taylor, T. A. (2002), p. 993.

Taylor (2002) has also studied the impact on sales effort on coordination. He found out that if sales effort has no impact on demand a target-rebate policy coordinates the channel. In this context a better supply chain performance cannot be reached by a linear-rebate policy.¹¹⁰

The rebate policy has also to be distinguished from a quantity discount policy. In the latter case the discount depends on the amount of goods being purchased by the retailer instead of realized sales.¹¹¹

According to supply channel coordination the sales-rebate contract can induce the same result as in the case of a revenue-sharing contract. Therefore, it is possible to calculate specific sales-rebate parameters which induce equal results. But it must be mentioned that the sales-rebate contract only induces the same performance in which the retailer is not a price-taker. The retail price is endogenously defined by the retailer. He can be seen as a price-setting newsvendor.¹¹²

Hence, different policies can be examined if they are achieving channel coordination. And so, we can distinguish between the following schemes:¹¹³

1. A target-rebate policy, and
2. a linear-rebate policy.

We will see that the two coordination mechanisms induce a better supply chain performance and that it is not always possible to induce a win-win-situation (both the manufacturer and the retailer are not worse-off).¹¹⁴

We will further see that a linear-rebate policy induces a better performance in contrast to the target-rebate policy without the assumption of win-win and under specific contractual agreements.

5.2 The model

Based on the assumption being already defined we further assume that the retailer cannot decide about the retail price. He is a price taker. In economic practice the retailers has often the

¹¹⁰ For details see Taylor, T. A. (2002), p. 993.

¹¹¹ See Taylor, T. A. (2002), p. 994.

¹¹² See Cachon, G. P., Lariviere, M. A. (2005), pp. 30-31.

¹¹³ See Taylor, T. A. (2002), pp. 992-993.

¹¹⁴ See Taylor, T.A. (2002), pp. 992-1007.

obligation to comply with a given price. Such standards defined by manufacturers are called as RPM (“*resale price maintenance*”) and MAP-policies (“*minimum advertised price*”).¹¹⁵

We assume further that the salvage value could be negative. This circumstance occurs if the retailer or the manufacturer has to dispose of leftover inventory.¹¹⁶ The granted rebate is expressed by the term α ($\alpha \in [0,1]$) and the threshold is expressed by the term T .

We will also examine the impact of mixed strategies to supply chain performance as in the case of HP, whereby the rebates are paid only in the case of sales realization. But first of all, we will study the target and linear rebate policy in detail.

5.3 The target-rebate policy and its consequences to supply chain performance¹¹⁷

The retailers profit function under a target-rebate policy if $\text{sales}^{\text{realized}} > T$ can be written as:

$$\pi_r^{\text{target-rebate}}(q, \alpha, T) = rS(q) - wq - c_r q - g_r(\mu - S(q)) + v(q - S(q)) + \alpha wq - \left[\alpha wT + \alpha w \int_T^q F(y) dy \right] \\ \text{for } q > T^{118}$$

As contrasted with Cachon (2003) the retailer receives a rebate payment in the amount of αwq (α is declared as percentage) minus the rebate payment to the threshold and the units unsold.

The retailer receives only a rebate payment for units sold. For units unsold he receives a salvage value per unit. In our analysis units unsold are expressed by the term $I(q) = q - S(q)$ (=leftover inventory). We further assume that $T = \beta q$, as $q > T$. In detail, the manufacturer grants a rebate on the amount of $\alpha\%$ above $\beta\%$ of unit's ordered. Hence, the retailers profit function can also be expressed as follows:

$$\pi_r^{\text{target-rebate}}(q, \alpha, T) = rS(q) - wq - c_r q - g_r(\mu - S(q)) + v(q - S(q)) + \alpha wq - \alpha w \left[\beta q + \int_{\beta q}^q F(y) dy \right]$$

¹¹⁵ See Taylor, T. A. (2002), p. 995.

¹¹⁶ See Taylor, T. A. (2002), p. 995.

¹¹⁷ In the style of Cachon, G. P. (2003), pp. 252-254 and Taylor, T. A. (2002), pp. 995-999.

¹¹⁸ See Cachon, G. P. (2003), p. 252.

Hence, the retailer receives a total rebate payment for all units ordered minus the threshold and leftover inventory for which he has no claim.

In the situation in which $\beta = 1$ the retailer does not receive a rebate payment due to the fact that $T = q$. On the other side in which $\beta = 0$ the retailer receives a payment on all units sold.

Hence, the solution under linear-rebate policy would be induced.¹¹⁹

The same applies to the situation in which $\alpha = 0$. Therefore, in both cases ($\beta = 1, \alpha = 0$) the supply chain performance of a price-only contract would be induced.

For further analysis we assume the following transfer-payment relating to the target-rebate policy:

$$T^{\text{target-rebate}} = \alpha w q - \alpha w \beta q - \alpha w (q - S(q))^{120}.$$

The retailer has a claim to a percentage of the wholesale-price times the ordered quantity minus the threshold and the rebate payment on the leftover-inventory for which he has no claim. Consequently, the retailers profit function is:

$$\pi_r^{\text{target-rebate}}(q, \alpha, T) = rS(q) - wq - c_r q - g_r(\mu - S(q)) + v(q - S(q)) + \alpha w q - \alpha w \beta q - \alpha w (q - S(q))$$

The first derivative of the retailers profit function yields to the following solution:

$$\frac{\partial \pi_r^{\text{target-rebate}}(q, \alpha, T)}{\partial q} = \frac{w + c_r - v + \alpha w \beta}{r + g_r - v + \alpha w} = S(q_r^*)'_{\text{target-rebate}}$$

If $\beta = 0$ the retailer receives for all units sold a rebate-payment in the amount of αw . In the situation in which the manufacturer does not grant a rebate ($\alpha = 0$) the same solution as in the case of a price-only contract would be induced. Consequently, if $\beta = 1$ and $\alpha = 0$ the solution of a price-only contract would also be induced.

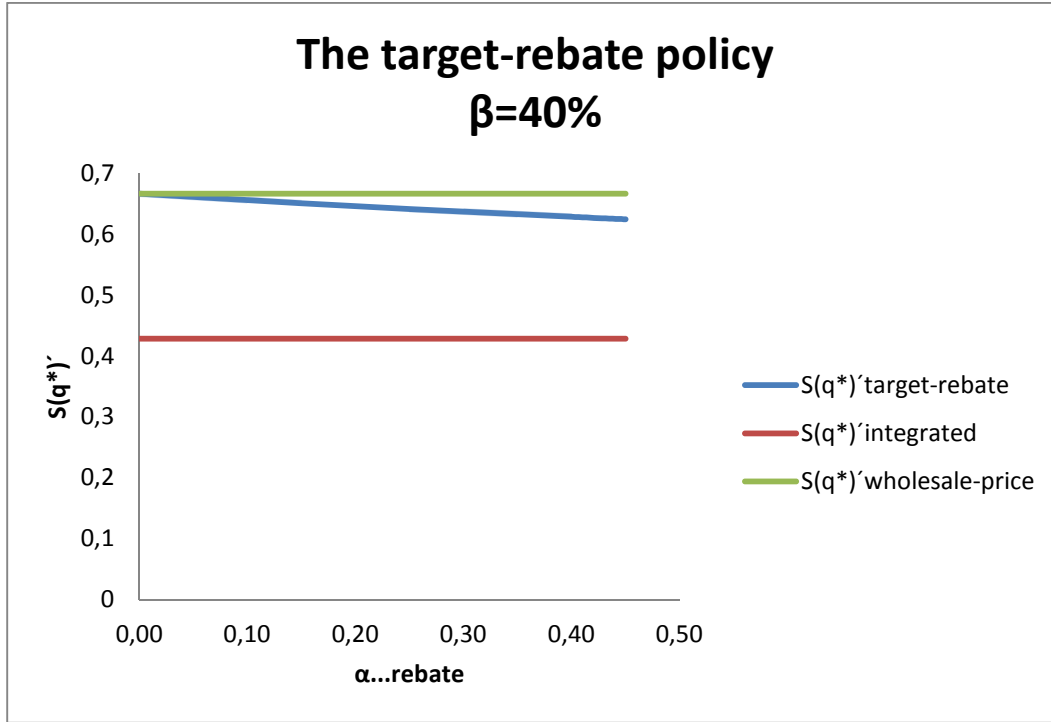
If we compare the first derivative of expected sales of a price-only contract, a sales rebate contract and the solution of the integrated channel we are able to state the following:

¹¹⁹ See pp. 38-41.

¹²⁰ For detail mathematical expression of the transfer-payment see Cachon, G. P. (2003), p. 252.

$$S(q_r^*)'_{integrated} < S(q_r^*)'_{sales-rebate} < S(q_r^*)'_{wholesale-price}$$

For the graphical illustration we assume the same data as defined in chapter 4.4. We further assume that $w > c_m$ and that the rebate α is between 1% and 45% and $\beta = 40\%$.

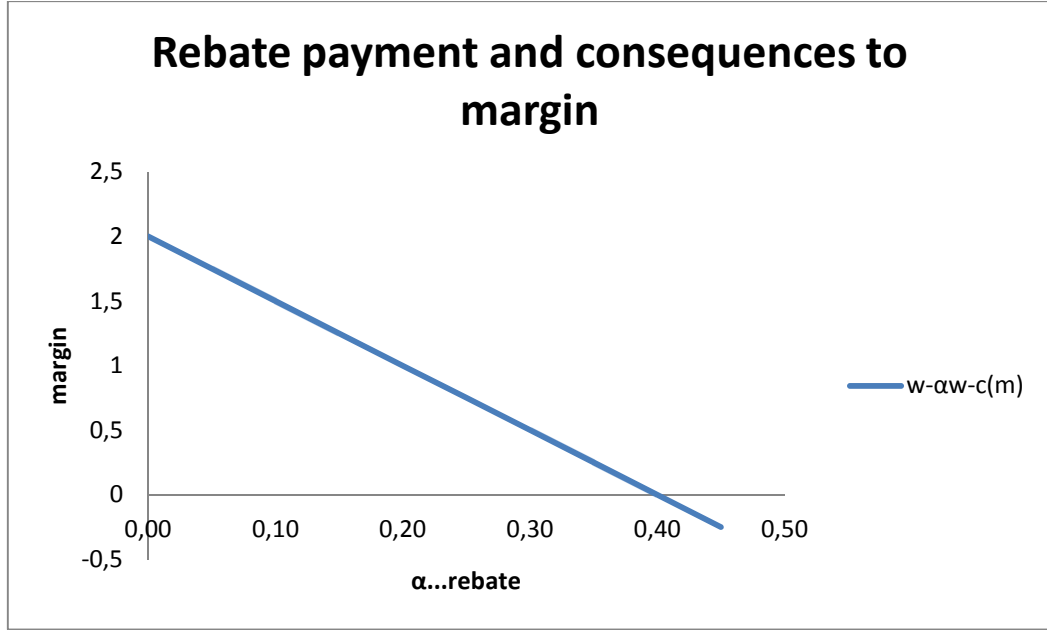


Graph 7

Graph 7 indicates that the target-rebate policy enhance the total supply chain performance. The manufacturer grants the retailer a price reduction of $-\alpha w$ for units sold above the threshold, therefore the manufacturers profit decreases and the retailers profit increases with increasing α .¹²¹

The following graph should demonstrate this case:

¹²¹ For details see Cachon, G. P. (2003), pp. 253-254 and Taylor, T. A. (2002), pp. 995-999.



Graph 8¹²²

If the manufacturer wants to induce the integrated supply chain performance and $w > c_m$ he has to choose αw as the difference between wholesale-price and his costs: $\alpha w = w - c_m$ and as result $w = c_m$. Hence, we have no double marginalization.¹²³ The manufacturer makes zero-profit and the retailer earns the total profit as in the case of an integrated business. Now, we examine the manufacturers profit function and assume $\beta = 0$ and the goodwill costs are zero:

$$\pi_m^{\text{rebate}} = wq - c_m q - \alpha w S(q).^{124}$$

The term $-\alpha w S(q)$ is the rebate-payment on expected sales which the manufacturer has to pay to the retailer. The first derivative in respect to q leads to the following solution:

$$\frac{\partial \pi_m^{\text{rebate}}}{\partial q} = w - c_m - \alpha w S(q)' = 0^{125}$$

¹²² For detail mathematical analysis compare with Cachon, G. P. (2003), pp. 253-254.

¹²³ See Spengler, J (1950).

¹²⁴ For another expression see Cachon, G. P. (2003), p. 253.

¹²⁵ Compare with Cachon, G. P. (2003), p. 254.

We assume $w > c_m$. The manufacturer has to choose the rebate-payment to induce the result of an integrated channel as follows:

$$\alpha w S(q)' = w - c_m$$

In such a situation the manufacturer would earn zero profit and the retailer would earn the total profit. Intuitively, as the rebate-payment increases the ratio of the manufacturers profit to the total supply chain profit decreases. Hence, the retailer receives with increasing rebate-payment the partial profit of the manufacturer.¹²⁶

In the next subchapter we will examine the linear-rebate policy and will compare it to the target-rebate policy.

5.4 The linear-rebate policy and its consequences to supply chain performance¹²⁷

The manufacturer pays the retailer a rebate in the amount of αw per unit sold. Therefore, the retailers profit function under a linear-rebate policy can be expressed as follows:

$$\begin{aligned}\pi_r^{linear-rebate} &= rS(q) - wq - c_r q - g_r(\mu - S(q)) + v(q - S(q)) + \alpha w q - \alpha w(q - S(q)) \\ \pi_r^{linear-rebate} &= rS(q) - wq - c_r q - g_r(\mu - S(q)) + v(q - S(q)) + \alpha w S(q)\end{aligned}$$

Hence, the manufacturer grants a rebate in the amount of all units ordered and sold minus the leftover-inventory:

$$T^{linear-rebate} = \alpha w q - \alpha w(q - S(q)).$$

For the correct rebate-payment the manufacturer has to verify the amount of units sold which is connected with an administrative burden. Therefore, the question arises if it is worth to enter into a linear-rebate agreement in contrast to a price-only contract. Hence, the manufacturer

¹²⁶ For detail mathematical analysis compare with Cachon, G. P. (2003), pp. 252-254 and Taylor, T. A. (2002), pp. 995-999.

¹²⁷ For detail mathematical analysis compare with Cachon, G. P. (2003), pp. 252-254 and Taylor, T. A. (2002), p. 996.

has to take into account the administrative costs which decrease his expected profit. For now we assume that the administrative costs are zero.

By differentiating the profit function with respect to q and receive:

$$S(q_r^*)'_{linear-rebate} = \frac{w + c_r - v}{r + g_r - v + \alpha w}$$

If we compare the results of a target-rebate and a linear-rebate policy the following can be stated in relation to the overall channel performance:

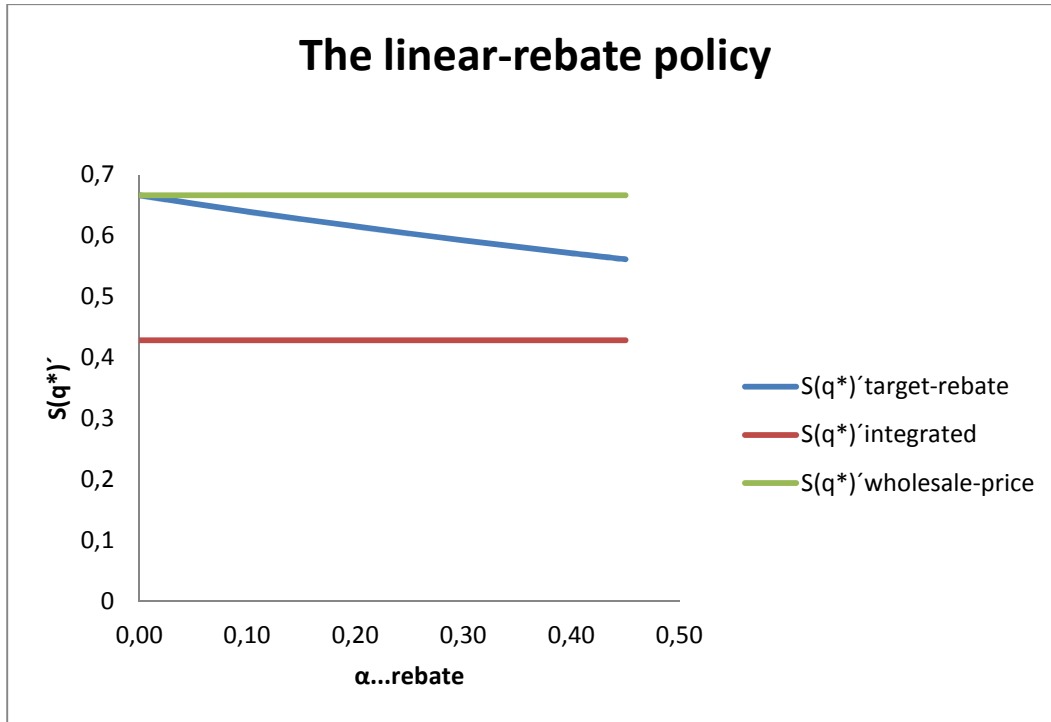
$$S(q_r^*)'_{wholesale-price} > S(q_r^*)'_{target-rebate} > S(q_r^*)'_{linear-rebate} > S(q_r^*)'_{integrated} .$$

The linear-rebate policy induces a better result in contrast to the target-rebate policy. However, the question arises if the linear contract is implementable.¹²⁸ Due to the fact that the manufacturer grants the retailer a price-reduction on every unit sold it could be the situation in which the manufacturer makes a loss or he has no profit. This would be in the case in which the margin does not cover the costs: $(w - \alpha w) < c_m$. Compared to the target-rebate policy this fact is of concern above the threshold. Taylor (2002) has assessed that coordination is possible but the manufacturer would incur a loss.¹²⁹ Also Cachon (2003) faced up to profit allocation with a precise analysis. He concludes that it is not possible to implement this type of contract to enhance supply chain performance in the case of “*voluntary compliance*”.¹³⁰ The following graph illustrates the consequences of a linear-rebate policy to supply chain performance:

¹²⁸ See Taylor, T. A. (2002), p. 992.

¹²⁹ For details see Taylor, T. A. (2002), p. 996.

¹³⁰ See Cachon, G. P. (2003), p. 254.



Graph 9

Graph 9 and 7 illustrates the above solution.¹³¹ In the situation in which $\alpha = 0$ the linear-rebate contract induces the same result as the price-only contract.

Hence, the linear-rebate policy induces a better supply chain performance in contrast to the target-linear policy and the wholesale-price contract. But it has been mentioned again that under specific contractual parameters the manufacturer would not participate.¹³²

But it could be a situation in which the manufacturer has a bargaining power whereby the manufacturer offers the retailer specific contractual parameters which can be seen as “take-it-or-leave it”¹³³ offer. So, the retailer does not reject the contract if his opportunity costs are covered. In such a case the retailer would make zero-profit and the manufacturer would receive the total supply chain profit.¹³⁴

In the case of a non-constant wholesale-price (dependent on quantity) a suitable profit sharing is possible without that one of the supply chain gets worse off (win-win-situation).¹³⁵

Taylor (2002) has also brought up the question if it is possible to induce contractual parameters inducing the same result as in the case of revenue-sharing. He concludes that it is not possible.¹³⁶

¹³¹ $S(q_r^*)'_{\text{wholesale-price}} > S(q_r^*)'_{\text{target-rebate}} > S(q_r^*)'_{\text{linear-rebate}} > S(q_r^*)'_{\text{integrated}}$.

¹³² See Taylor, T. A. (2002), p. 995 and Cachon, G. P. (2003), p. 254.

¹³³ See Taylor, T. A. (2002), p. 996.

¹³⁴ See Taylor, T. A. (2002), p. 996.

¹³⁵ For details see Taylor, T. A. (2002), p. 997.

Since profit of the retailer in a revenue-sharing contract is $\phi r - w_{\text{revenue-sharing}}$ and under a linear-rebate policy is $r + \alpha w_{\text{rebate}} - w_{\text{rebate}}$. By equation of the wholesale-prices the rebate-payment αw would be negative. Hence, a revenue-sharing contract differs from a linear-rebate and target-rebate policy.

In the next chapter we will compare the quantity-discount policy (in which the retailer receives a rebate payment on each unit purchased) to the linear-rebate policy (in which the retailer receives a rebate payment on each unit sold).

5.5 The quantity-discount policy and its consequences to supply chain performance¹³⁷

The retailers profit function under a quantity-discount agreement would be:

$$\pi_r^{\text{quantity-discount}} = rS(q) - wq - c_r q - g_r(\mu - S(q)) + v(q - S(q)) + \alpha wq$$

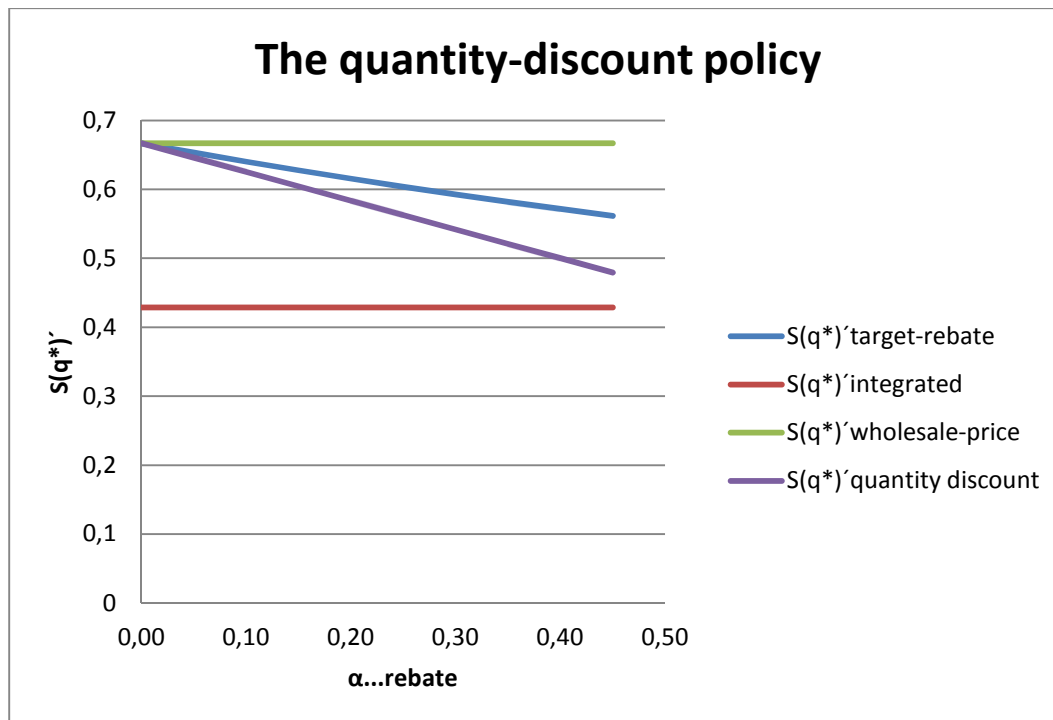
The retailer receives for every unit purchased a rebate payment in the amount of αw . The first derivative of the retailers profit function is

$$S(q_r^*)'_{\text{quantity-discount}} = \frac{w + c_r - v - \alpha w}{r + g_r - v}.$$

The following graph should demonstrate the above solution.

¹³⁶ See Taylor, T. A. (2002), p. 997.

¹³⁷ For detail mathematical analysis see Cachon, G. P. (2003), pp. 254-255.



Graph 10

Hence, the quantity-discount policy enhances the supply chain performance in contrast to the linear-rebate policy. It is also possible to induce the performance of an integrated channel as far as the manufacturer increases the rebate payment to a specific amount. In our case it would be in the situation in which the violet line crosses the red line.

5.6 Summary

Receiving a better supply chain performance and thereby insuring that no party gets worse off (a situation in which all parties involved in the supply chain make a profit) implies that the manufacturer has to know the demand distribution in order to offer the retailer suitable contractual parameters.¹³⁸

Hence, linear-rebate and target-rebate policies achieve a better supply chain performance but they are not practicable in relation to outcomes. Taylor (2002) have therefore designed a contract in which the retailer can give back unsold goods at an agreed value and receives a target-rebate for sold goods under the assumption of retailers sales effort. Such a contract is practicable and implementable.¹³⁹

¹³⁸ See Taylor, T. A. (2002), p. 998.

¹³⁹ For detail mathematical analysis see Taylor, T. A. (2002), pp. 999-1005.

6. The quantity-flexibility contract¹⁴⁰

6.1 Introduction

Under a quantity-flexibility contract the manufacturer pays the retailer the losses on unsold inventory. In contrast to the buyback contract the manufacturer fully takes on the risks of unsold units. Hence, the quantity flexibility contract fully secures the retailer on his order.¹⁴¹ The question arises if such a policy in the described manner could be effective and will be implemented in economic practice. If the retailer gets on the total amount of unsold goods a compensation in the amount of his losses he would not bear a risk being resulting in an inefficient ordering system.

It has to be noticed that an additional contract parameter must be implemented to avoid the described scenario. Hence, under a quantity-flexibility contract only a fraction of unsold inventory is compensated by the manufacturer.¹⁴²

A lot of companies can be named which are using the concept of a quantity-flexibility contract. Examples are Microsystems, Nippon Otis, Solelectron, Toyota Motor Corporation, Hewlett Packard and Compaq.¹⁴³

In the case in which the manufacturer pays the retailer a partial of his losses measured according to an agreed fraction of unsold goods we have a special form of a quantity-flexibility contract being studied in the literature extensively. It is called a backup agreement.¹⁴⁴ In the research of Eppen and Iyer (1997) the retailer (=catalog-company) communicates the total order and orders a part of it at the beginning of the period. After the retailer has observed the first demand signal he orders from the backup-quantity. In the case of not ordering the total backup-quantity the retailer has to pay a penalty on leftover backup-quantity.¹⁴⁵ This procedure is applicable in industries with long cycle times, a high percentage of uncertainty, a high degree of returned units and the possibility to adapt the number of units.¹⁴⁶

The quantity-flexibility contract was studied intensively by Tsay and Lovejoy (1999). In their model they defined a number of processing times, demand periods and demand forecast actu-

¹⁴⁰ Based on Cachon, G. P. (2003), pp. 248-252.

¹⁴¹ See Cachon, G. P. (2003), p. 248.

¹⁴² See Cachon, G. P. (2003), p. 248.

¹⁴³ For details see Tsay, A. A. (1999), p. 1340.

¹⁴⁴ See Cachon, G. P. (2003), p. 248 and for details see Eppen, G. D., Iyer, A. V. (1997) pp. 1469-1483.

¹⁴⁵ See Eppen, G. D., Iyer, A. V. (1997), p. 1469.

¹⁴⁶ For details see Eppen, G. D., Iyer, A. V. (1997), p. 1469.

alizations.¹⁴⁷ Therefore, to answer our question regarding to supply chain performance and the effectiveness regarding to decreasing of the double marginalization effect their complex scientific paper is not qualified in that context.

In this context it has to be mentioned the “rolling-horizon-flexibility contract” (Bassok and Anupindi 2008). Under such an agreement the retailer communicates in every period in advance in every period the needed quantity. After the retailer has recognized a demand signal he has the possibility through a contractual agreed percentage to alter his order (e.g. the retailer communicates a specified order quantity for period 2 which can be adapted by plus/minus 10%).¹⁴⁸ In their study they give an insight into the characteristics of rolling-horizon-flexibility contracts regarding to effectiveness through two heuristics.¹⁴⁹

Hence, uncertain demands, the behavior of over forecasting and information asymmetry are the main reasons for developing different types of quantity flexibility contracts.¹⁵⁰ Effectively the retailer has to pay more for more flexibility because of additional inventory carrying costs arising at the manufacturer. Therefore, the manufacturer is faced with long production and procurement times implying inflexibility and so a higher build-up inventory is necessary to meet consumer demand in a short period.¹⁵¹ However, the manufacturer could also agree with a lower price per unit in return for more certainty regarding to forecasting.¹⁵²

How important a quantity flexibility contract regarding to supply chain performance might be can be demonstrated by the following example from economic practice:¹⁵³ Mattel a supplier of toys relied on higher sales after Thanksgiving in the year 1998. However, the retailers could not place their orders as expected. As a consequence Mattel incurred a loss in the amount of \$500 million. Mattel responded to that loss by signing the retailers to place their orders before Thanksgiving in order to avoid creating unnecessary stock of inventory. Therefore, Mattel does not offer flexibility which could lead to supply chain inefficiencies. Mattel has not reacted correctly because of the fact that there are possibilities to implement flexibility mechanisms decreasing the risk and leading to a win-win situation and therefore to a better supply chain performance.¹⁵⁴

¹⁴⁷ See Cachon, G. P. (2003), p. 251.

¹⁴⁸ For details see Bassok, Y., Anupindi, R. (2008), p. 460.

¹⁴⁹ For details see Bassok, Y., Anupindi, R. (2008), p. 473.

¹⁵⁰ See Tsay, A. A. (1999), p. 1356.

¹⁵¹ See Schuster-Barnes, D., Bassok, Y., Anupindi, R. (2002), p. 171.

¹⁵² See Tsay, A. A. (1999), p. 1356-1357.

¹⁵³ See Schuster-Barnes, D., Bassok, Y., Anupindi, R. (2002), pp. 171-172.

¹⁵⁴ See Schuster-Barnes, D., Bassok, Y., Anupindi, R. (2002), p. 172.

Another type of contract in that context is the pay-to-delay contract which is often used in the Semiconductor-industry. The supplier has the possibility to make his order at a later time but has to make a prepayment which will replace the procurement costs.¹⁵⁵

For further analysis and the answer regarding to supply chain efficiency as well as the double-marginalization effect the scientific paper of Cachon 2003 is qualified best.¹⁵⁶ Therefore, we define in the next chapter the model under a quantity-flexibility contract with total and partial compensation in a one-period model. Afterwards we analyze supply chain performance with regard to the double marginalization effect.

6.2 The model

The manufacturer pays the retailer a payment in the amount of

$$T = w + c_r - v. \quad ^{157}$$

The retailer receives that payment on his leftover inventory or on a part of his unsold units which will be expressed by the term $\omega \in [0,1]$.¹⁵⁸ Therefore, the retailer agrees to the contractual terms T and ω being specified by the manufacturer.¹⁵⁹

Hence, we can distinguish between the following two contractual agreements:

1. The retailer receives a payment in the amount of T on the total amount of leftover inventory or
2. the retailer receives a payment in the amount of T on a part of unsold units.

In the first contractual agreement it is important to keep in mind that the supplier gives a wrong incentive. In that case the retailer would order without considering consumer demand leading to an inefficient supply chain. He would order as much as possible to cover demand without punishment to increase his profit. Therefore, for further calculation we take only the second contractual agreement.

¹⁵⁵ See Schuster-Barnes, D., Bassok, Y., Anupindi, R. (2002), p. 172 and for details see Brown, A. O., Hau L. Lee (1997) and Jun Wu, Wuyi Yue, Yoshitsugu Yamamoto, Shouvang Wang (2006).

¹⁵⁶ See Cachon, G. P. (2003), p. 248-252.

¹⁵⁷ See Cachon, G. P. (2003), p. 248.

¹⁵⁸ Compare with Cachon, G. P. (2003), p. 248.

¹⁵⁹ See Cachon, G. P. (2003), pp. 248-249.

6.3 The quantity-flexibility contract and its consequences to supply chain performance

In this chapter we will analyze the supply chain performance under second contractual agreement in detail to assess whether the flexibility contract in the above manner decreases the double-marginalization effect and hence coordinates the supply chain.

The retailers profit function under the second contractual agreement is:

$$\pi_r = (r - v + g_r)S(q) - (c_r - v)q - \mu g_r - wq + (w + c_r - v)(q - S(q))\omega$$

or

$$\pi_r = (r - v + g_r)S(q) - (c_r - v)q - \mu g_r - wq + (w + c_r - v) \int_{(1-\omega)q}^q F(y)dy^{160}$$

The payment under the second contractual agreement takes place only on a fraction of unsold goods.

Hence, from the viewpoint of the manufacturer it is necessary to differentiate the above profit function to q to calculate the optimal supply chain units under the quantity-flexibility contract. Therefore, the first derivative of the retailers profit function is:

$$\frac{\partial \pi_r}{\partial q} = S(q_r^*)'_{\text{quantity-flexibility}} = \frac{(w + c_r - v)(1 - F(q^*) + (1 - \omega)F((1 - \omega)q^*))}{r - v + g_r}^{161}$$

If we compare the result under a wholesale-price contract with the above formula we can assess the following:

$$S(q_r^*)'_{\text{wholesale-price}} = \frac{w + c_r - v}{r - v + g_r} > S(q_r^*)'_{\text{quantity-flexibility}} = \frac{(w + c_r - v)(1 - F(q^*) + (1 - \omega)F((1 - \omega)q^*))}{r - v + g_r}$$

¹⁶²

The quantity-flexibility contract in which a portion of the unsold goods underlie a compensation paid by the manufacturer can be seen as a coordination mechanism. Under the above contractual agreement the retailer would order more and overall supply chain performance would

¹⁶⁰ See Cachon, G. P. (2003), p. 249.

¹⁶¹ See Cachon, G. P. (2003), p. 249.

¹⁶² See Cachon, G. P. (2003), p. 238.

increase. Notice that the manufacturer acts again like a “Stackelberg-leader”. He decides about the contract terms and forces the retailer to act under his interests.¹⁶³

To show how the quantity-flexibility contract decreases the double-marginalization effect we calculate from the first derivative the wholesale-price as a function of the fraction of unsold goods and receive:

$$w(\omega)_{\text{quantity-flexibility}} = \frac{(r - v + g_r)(1 - F(q^*))}{1 - F(q^*) + (1 - \omega)F((1 - \omega)q^*)} - c_r + v. \quad 164$$

If we compare the above wholesale-price to the wholesale-price calculated from the first derivative under a price-only contract we can assess the following:

$$w_{\text{price-only}} = (r - v + g_r)S(q^*)' - c_r + v > w(\omega)_{\text{quantity-flexibility}}. \quad 165$$

The manufacturer induces the optimal quantity (like in an integrated channel) if he sets his costs to the wholesale-price ($w = c_s$). In this situation the manufacturer would earn zero-profit and the retailer would earn the total supply chain profit.

In the case of a price-only contract in which $w > c_s$ we recognize the double-marginalization effect. If we compare the wholesale-prices of a price-only contract and a quantity-flexibility contract as calculated above we see that the wholesale-price under the price-only agreement is higher as the wholesale-price under the quantity-flexibility agreement. Hence, the wholesale-price as a function of the fraction of unsold goods induces a better supply chain performance as in the case of a price-only contract. Therefore, the double-marginalization effect is minimized by the quantity-flexibility agreement.

In the case in which $\omega = 0$ the solution of a price-only contract will be induced:

$$\begin{aligned} w(0) &= (r - v + g_r)S(q^*) + v - c_r \\ S(q^*)' &= \frac{w(0) + c_r - v}{r - v + g_r} \end{aligned} \quad 166$$

In the case in which $\omega = 1$ the following result can be recognized:

¹⁶³ For the distinguishment of forced and voluntary compliance see Cachon, G. P. (2003), p. 235.

¹⁶⁴ See Cachon, G. P. (2003), p. 249.

¹⁶⁵ For calculating the wholesale-price in a price-only contract see Cachon, G. P. (2003), p. 238.

¹⁶⁶ See Cachon, G. P. (2003), p. 250.

$$w(1) = r - v + g_r - c_r + v \quad ^{167}$$

$$w(1) = r - c_r + g_r$$

Hence, the wholesale-price under a quantity-flexibility agreement has to be between:

$$v - c_r \leq w(\omega) \leq r - c_r + g_r. \quad ^{168}$$

6.4 Summary

In this section we can conclude that the quantity-flexibility contract induces a better supply chain performance and reduces the double-marginalization effect.

To which extent the different profit shares are split between the manufacturer and the retailer depends on the fraction of unsold goods compensated.¹⁶⁹

¹⁶⁷ See Cachon, G. P. (2003), p. 250.

¹⁶⁸ See Cachon, G. P. (2003), p. 250.

¹⁶⁹ For details see Cachon, G. P. (2003), p. 251.

7. Conclusion

The revenue-sharing, the buyback, the sales-rebate and the quantity-flexibility contract are suitable as coordination mechanisms with the exception of the wholesale-price contract. They provide an incentive to the retailer to order more and total supply chain profit increases. With increasing supply chain profits the efficiency of the supply chain also increases independent of profit allocation.

In specific cases the supply chain would be better off in contrast to the presented coordination arrangements. Because coordinating contracts cause an administrative burden their implementation would be more difficult in the sense of system efficiency. And consequently, the attractiveness of the wholesale-price contract increases. Especially in the cases in which demand follows a power-function distribution with decreasing relative variability and in the case of concavity of marginal revenue curve the degree of supply chain inefficiency decreases.¹⁷⁰

Under a revenue-sharing agreement the manufacturer has to set his wholesale-price below his costs to achieve coordination. Effort costs which are spent to increase consumer demand needs to be fairly shared so that nobody in the supply chain gets worse off.

Under a buy-back agreement three possibilities for improving the supply chain were presented. The agreement in which the manufacturer buys a partial of unsold goods back at full value has induced the best performance corresponding with economic practice (reported in the Wall Street Journal, February 18, 1982¹⁷¹). Further, the buy-back contract induces the same result as in the case of revenue-sharing by equation and substituting.

We have ascertained that a target-rebate policy reduces the manufacturer's profit above the threshold and increases the retailer's profit. The linear-rebate policy induces a better supply chain performance in contrast to the target-rebate policy but under specific contractual parameters the manufacturer would not participate.¹⁷² In such a case he would make a loss or zero profit. Further a linear-sales rebate contract could never induce the same result as in the case of a revenue-sharing contract.

¹⁷⁰ See Lariviere, M. A., Porteus, E. L. (2001), p. 294 and Cachon, G. P., Lariviere, M. A. (2005), p. 39.

¹⁷¹ See Pasternack, B. A. (1985), p. 134.

¹⁷² See p. 35-36

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Abstract in English

This paper has a focus on supply chain inefficiency based on the problem of “double marginalization” and consequently non-optimal ordering quantity. Well-known scientists have grappled critically with coordinating contracts in a mathematical way to investigate them with respect to total-profit efficiency. On the basis of their intensive research this paper gives the answer for how “double-marginalization” arises, which contracts exist in economic practice and which of them coordinates the supply chain with regard to increasing total supply chain profit.

Abstract in German

Der Fokus dieser Diplomarbeit liegt auf dem Problem der “doppelten Marginalisierung” und den daraus resultierenden Konsequenzen für die Wertschöpfungskette.

Sehr bekannte und renommierte Wissenschaftler haben sich mathematisch mit koordinierenden Mechanismen in Form von Verträgen befasst, die bereits in der Praxis ihre Anwendung finden. Basierend auf ihren Erkenntnissen, wird in dieser Diplomarbeit zunächst die Entstehung der “doppelten Marginalisierung” thematisiert. Weiters wird erläutert, welche Verträge in diesem Bereich existieren und welche geeignet erscheinen, die Wertschöpfungskette in Bezug auf die Gesamtperformance zu koordinieren, um sie effizienter zu gestalten.

Curriculum Vitae

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