Chapter 9
Risk Intermediation in Supply Chains

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Abstract In some supply chains, retailers are relatively small and averse to taking risk. In such a situation, traditional methods of contracting, that typically assume risk neutrality on retailers, might not suffice to maximize the seller’s/distributor’s expected profit. We present tools for analyzing and solving such a problem from the viewpoint of a (risk-neutral) seller/distributor. We present two types of models that can be used to create contracts, one set in a discrete setting and the other in a continuous setting. In both settings, individual retailers are characterized with different degrees of risk aversion.

We first explain in the discrete setting how the varying degrees of risk aversion present hurdle for the design of a uniform contract for all retailers. We then show how to mitigate the problem using ideas from the theory of mechanism design. We offer a simple solution to the contract design problem and show how it can be easily implemented. We next show that in the continuous setting in which the distribution of retailers is continuous, which could be viewed as a limiting case of the discrete setting, the contract design problem actually simplifies. In this continuous setting, we show that it becomes relatively easy to design contracts and establish their optimality from the seller’s/distributor’s viewpoint. We conclude the chapter with a summary of problems that are still open in this area.

9.1 Introduction

We consider a single period model in which multiple risk-averse retailers purchase a single product from a common vendor. We assume that the retailers operate in identical and independent markets. The retailers face uncertain customer demand and accordingly make their purchase order quantity decisions in order to maximize their expected utility. The vendor offers the same supply contract to each retailer. The terms of the contract offered to the retailers are similar to the ones found in the classical newsvendor problem. Under this contract, each retailer purchases a certain
quantity at a regular purchase price. If the realized demand is greater than the quantity ordered then the retailer has the option to purchase the units that are short at an emergency purchase price which is higher than the regular price. If the demand is less than the order quantity then the retailer has the option to return the leftover inventory at a salvage price that is lower than the regular price. (This contract is referred to in what follows as the original newsvendor contract (ONC).) The retailers are price takers and sell the product at the same fixed price. The problem of deciding upon the quantity to order from the vendor is similar to the classic newsvendor problem, except that due to risk aversion, each retailer maximizes his expected utility rather than his expected profit. The problem faced by a newsvendor is known as the “risk-averse newsvendor problem”.

This problem has been well studied in the literature. In particular is well known that the risk-averse retailer’s order quantity (i.e., the one that maximizes his expected utility) will be smaller than the order quantity that maximizes his expected profit (see Horowitz, 1970; Baron, 1973; Eeckhoudt et al., 1995). Obviously, the reduction in the order quantity of the retailer leads to a lower expected profit (for the retailer) compared to the expected profit obtained under the profit maximizing order quantity. Eeckhoudt et al. give examples in which risk averse retailers will order nothing due to high demand uncertainty. Therefore, risk aversion of the retailers has been portrayed in the literature as leading to the loss of efficiency in supply chains. (We use the term “efficiency” to refer to the combined expected profit of the seller and the retailer. In general, this term refers to the total expected profit of all participants in a supply chain.)

In this chapter we show not only that this loss of efficiency can be eliminated through risk reducing pricing contracts but also that any risk neutral intermediary will find it beneficial to offer such risk reducing contracts to the retailers. In our model, the intermediary is referred to as the distributor\(^1\) and purchases the goods as per the terms of the ONC from the vendor. In turn the distributor offers the goods to the retailers on contract terms that are less risky from the retailers’ viewpoint, namely: We propose that, as opposed to the ONC, under the risk reducing contracts offered by the distributor to the retailers, the emergency purchase and the salvage prices should be set equal to the regular purchase price, and that in addition a fixed payment should be made by the distributor to the retailer. Therefore, a retailer’s payoff consists of a fixed component (independent of the demand) and a variable component that increases linearly with the realized demand. Consequently, as the retailer’s payoff depends only upon the demand, the retailer is indifferent to the order quantity decision and is content to relegate the responsibility of determining an order quantity to the distributor. The distributor makes the order quantity decision fully aware that he has to satisfy all the demand faced by the retailer. Thus the distributor bears the cost if necessary of buying the product at the emergency purchase cost and

\(^1\) The distributor can be an independent firm, the vendor, or one of the retailers. For the sake of clarity we will refer to the intermediary as the Distributor, and the risk averse players facing uncertain demand as the Retailers. The analysis, though, is valid for any two levels in a vertical marketing channel, where the lower level facing uncertain demand is risk averse and the upper level is risk neutral (or less risk averse).