Summary Brief
Supply Chain Coordination: Allocations, Limitations, and Impediments

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Abstract
A large body of supply chain literature addresses the issue of supply chain coordination via contracts. The bulk of this research examines what contract types can coordinate the supply chain under various demand scenarios. The issue of what contracts will actually be implemented, and what the parameters of those contracts will be, has received considerably less attention.

This paper will examine the practicality of implementing the coordinating buyback contract in a single period newsvendor scenario. Using the accepted models of contract coordination we extend the analysis to determine the potential gain from coordination, and the Nash equilibrium division of those gains. We next examine issues that may prevent the formation of a coordinating contract, specifically transaction costs and risk aversion. We find that for moderate levels of transaction cost and risk aversion, the coordinating contract may become Pareto inferior to the wholesale contract.

Introduction
This paper examines the feasibility of implementing a coordinating contract in a single period newsvendor scenario. Specifically we examine the buyback contract when transaction costs are non-zero and suppliers are risk averse. Following the established coordination literature we show that a buyback contract can coordinate the supply chain, and that under a common set of assumptions, this contract Pareto dominates the wholesale contract. We go on to calculate the gains from coordination for the supply chain as a whole and the range of potential gains for each party. We furthermore show that the range of profit allocation parameters is limited for Pareto dominant contracts, and use a simple bargaining model to determine an equilibrium division of gains. We next evaluate impediments to implementing the coordinating contract, specifically transaction costs and supplier risk aversion. We show how these issues reduce the set of feasible contracts. We provide a numerical illustration of the of the coordination problem. We assume uniform demand and then calculate the parameters for a wholesale and buyback contract scenario demonstrating an expansion of output and supply chain profits. We then go on to calculate the range of transaction costs and risk aversion parameters that render this coordinating contract Pareto inferior to the wholesale contract.

Supply Chain Coordination
Supply Chain Coordination literature addresses an issue associated with a supply chain composed of independent firms; the fact that in the presence of market power, optimal decision making at the firm level sub-optimizes the profit of the entire supply chain. This issue has been widely addressed in the economics literature under the general heading of vertical control (Tirole 1988), and in the marketing literature under the heading of channel coordination (Jeuland and Shugan, 1983). The problem arises because the retailer’s cost includes the profit of the supplier. Since her marginal costs are higher then that would be faced by an integrated firm, the retailer chooses a stocking level below what would be chosen by an integrated firm.

Coordination of the supply chain concerns the design of an incentive aligning contract that motivates the supplier and retailer to operate so as to maximize the profit of the entire supply chain. In general, the literature examines the mechanisms which can be used to modify the marginal cost of the retailer so as to motivate her to make the same decisions an integrated firm would make (Cachon 2003). The literature shows that under a wide range of circumstances, there are multiple contract forms which can coordinate the supply chain. Furthermore these contracts are shown to be Pareto efficient, that is, all parties are better off under the coordinating contract. Since each party is better off we would expect coordinating contracts to be widely implemented in practice, yet this is not the case. The purpose of this analysis will be to examine a few of the practical limitations that may prevent a coordinating contract from being implemented.

Basic Model and Coordination Gains
We develop a basic model for the supply chain coordination problem largely derived from Cachon’s review (2003). We confirm that when both supplier and retailer have pricing power, a wholesale contract causes the retailer choose a quantity that sub-optimizes supply chain profit. This is due to the well known problem of double marginalization (Spengler 1950). We also confirm that a buyback contract can be structured to achieve the supply chain optimal quantity and coordinate the supply chain.

Our analysis goes on to calculate the expected gains from coordination, both in terms of quantities and profits, as a function of costs and the probability distribution of demand. The division of additional profits between supplier and retailer is analyzed using a Nash bargaining model (Nash 1950) and an equilibrium division is identified. We highlight the fact that the supplier induces a higher level of output by absorbing some of the risk borne by the retailer under a wholesale contract. We are able to calculate the probability that the actual realization of demand will be such that the realized gain for the supplier will be negative. As shown in Cachon (2003) the buyback contract can be configured with a single parameter, λ, the allocation of profit between supplier and retailer. We show, and illustrate with a numerical example, that the range of allocations for which the buyback contract is Pareto superior is limited. Using a Nash bargaining model we calculate the equilibrium value of λ, the value that evenly divides the gains from coordination between the supplier and retailer. In summary, this analysis shows that a supplier can offer a buyback contract that results in a strictly greater order...
quantity and expected supply chain profit in return for the transfer of a portion of the demand risk from retailer to supplier.

Inefficiencies and Impediments

Having evaluated the contract under the standard set of assumptions, we next examine the impact of two real-world impediments. Because the fundamental trade-off for the supplier is between expected profit and risk, we examine the impact of supplier risk aversion. We also examine the issue of transaction costs, because the cost of implementing and administering a buyback contract can erode the gains from coordination. (Note: recent news reports illustrate the high costs associated with returns in the book industry, one of the few industries where buybacks are common (Trachtenberg 2005)). Other recent articles highlight the supplier’s risk associated with returns in the DVD industry, another industry where buybacks are common. We assume transaction costs are fixed and calculate the maximum per unit value that eliminates the gains from coordination. We treat risk aversion first by calculating the probability that the supplier will realize lower profits under the buyback contract than under the wholesale contract. We then introduce a concavity utility function for the supplier that allows us to calculate the level of risk aversion that renders the buyback contract Pareto inferior.

Numerical Example

To better illustrate the findings of our analysis, we next develop a straightforward numerical example. We assume demand is uniformly distributed between 0 and 1. We assume a retail price of 10, manufacturing costs of 4, and retail distribution costs of 2. Using this data, we go on to show that the buyback contract, when configured as suggested in the literature, causes the retailer to double the order quantity. Expected profits for the supply chain increase from .6 to .8, with the gain shared equally between the supplier and retailer. We show however, that this contract forces the supplier to offer to buyback items at 95% of the original wholesale price. In return for a 50% increase in expected profit, the supplier has increased her risk; with a probability of 32%, she will earn less under the buyback contract. We then introduce the issues of transaction costs and risk aversion. We show that for absent any risk aversion, a transaction cost equal to 5% of the retail price eliminates the gains from coordination. Absent transaction costs, a risk coefficient of .73 renders the utility of the buyback contract inferior to the wholesale contract from the supplier’s perspective. We then evaluate the combined effects of risk aversion and transaction costs and show that when both issues exist, the buyback contract quickly becomes Pareto inferior.

Discussion

The purpose of this manuscript was to investigate the real world issues associated with supply chain coordinating contracts. The analysis is motivated by the observation that coordinating contracts are rare in practice, and in at least some industries in which they do exist, they are problematic for the supplier. We began with a simple model widely used in the coordinating literature and extended it first to calculate the range of parameters under which the buyback contract Pareto dominates the wholesale contract. We then introduce two factors that further limit the viability of the buyback contract. Through a simple numerical example, we demonstrate that the buyback contract may be Pareto inferior under a set of reasonable assumptions about risk aversion and transaction costs. Further analysis is required for a more empirical test of the hypothesis put forward in this paper; that is, that the scenarios under which a buyback contract is desirable to the supplier are relatively limited.

References


