2
Literature review

Most of the literature about coordination of companies by formal contracts developed in the 90's decade derives from classic inventory control literature and treats extensions of the newsvendor problem. The studies are centered on one of the companies in the supply chain aiming to maximize its performance, where the supply chain is usually the most simple structure of a dyad formed by two companies. Due to the simplicity of the newsvendor model, it has been studied, and used, extensively by several authors to get insights into aspects involved in the dyad coordination that are relevant to the analysis and design of contracts. For example, Cachon (2003) uses the newsvendor model to explore three important issues to be addressed in supply chain coordination by contracts, namely: (i) what contracts coordinate the supply chain, (ii) what contracts have the flexibility to allow arbitrary allocation of the gain obtained in the supply chain, and (iii) what contracts are worth to be adopted in the sense of viable implementation. In this work, it is used the convention adopted by Cachon (2003) in which the company offering the contract is female and the accepting one is male and, when neither company offers the contract, the upstream company is female and the downstream one is male.

Usually, the study of contracts centered in one company under some manufacturing setting, for which the basic assumptions of the newsvendor model are satisfied, results in problems easy to solve. When this is not the case, models' solutions are, usually, not closed form expressions leading to more complicated analyses. Modeling becomes more complex in studies focused on the dyad, because the dependence that the decisions of a company have in the decisions of the other one must be incorporated in the modeling. That complexity is present in the analysis of a dyad formed by a retailer and a supplier company assumed to be a manufacturer. It is exacerbated when the dyad is comprised by two manufacturers because both companies face risky medium-term capacity decisions since they are made before knowing the actual future market demand. Despite reduced possibility of getting general qualitative results about the contract being analyzed, the dyad problems for manufacturers can be treated numerically in order to get the solution under a

given setting.

In the recent literature, several contracts have been defined with the purpose of improving the individual performance of each company and, consequently, the dyad's performance. In addition, different types of contracts have been proposed to address the issues exposed by Cachon (2003), that is, contracts that lead to dyad coordination, arbitrary allocation of the gain and, also, a viable implementation. Some industries present characteristics that promote the study of a particular type of contract. For example, the retailers in the videocassette rental industry offer their products displaying the boxes of available copies, from which the customers make their selections, and have an available information system that allows monitoring their sales. The low sale effort and the possibility of verifying the retailer's revenues are distinctive characteristics that stimulate the adoption of revenue-sharing contracts. On the other hand, the high-tech industry is characterized by capital intensive production and highly skilled labor, short product life-cycle, and the nearly continuous technological innovation. Consequently, the expansion of manufacturing capacity involves very high risk, whereby the supplier seeks opportunities for hedging and risk sharing by means of capacity reservation contracts.

Diverse issues must be addressed in the analysis and design of contracts, from the formulation of models, which can differ considerably according to the manufacturing setting and the assumptions considered, to the solution procedures specially defined to solve the problems derived from the analysis, which can comprise exact methods or heuristics for getting numerical solutions. Therefore, it is important to stress the existence of many papers that treat specific issues involved in the coordination of the companies' capacity decisions. For example, models and procedures to solve production planning problems with stochastic demand and multi-period planning horizon are developed by Bitran and Yanasse (1984), Escudero et al. (1993), Ciarallo et al. (1994), Minner (1997, 2003, 2005, 2007) Yildirim et al. (2005), Rockafellar and Wets (1991), and Alonso-Ayuso et al. (2005). See Silver, Pyke and Peterson (1998) and Mula et al. (2006) for literature reviews about models for planning production under uncertainty.

In the sequel, some papers that treat the analysis of a contract centered on the performance of a single company in the dyad are shortly commented in Section 2.1. A taxonomic classification for the papers that are directly related to this work is proposed in Section 2.2 and summarized in Table 2.1. The types of contract more frequently treated in the SCM literature are also briefly presented, and are analyzed in the papers commented later on. Finally, some comparisons between the analysis of the contract proposed in this dissertation

and the ones treated in the literature are made in Section 2.3.

2.1 Analysis of contracts centered on single company performance

According to Anupindi and Bassok (2002), the classical inventory theory can be seen as a specific type of contracts, in which imperfect competition has received little attention. In particular, the newsvendor problem can be considered as the analysis of a contract in a setting characterized by a given planning horizon, an unit purchasing price (which is often considered fixed), with fixed periodic order, no purchase or reserve commitments, an unlimited flexibility (usually, there is no bound for the quantity to be ordered), delivery within fixed supply lead-time, and single shipment for each order. From the contractual point of view, the inventory policy (s,S) (or reorder point and order-up-to-level) can be viewed as the result of the analysis of a contract centered on the buyer who has some transaction cost, or who does not have internal transaction costs but the pricing policy is a two-part tariff (fixed fee plus a linear variable part). While inventory policy (Q,R) can be considered as the outcome of a newsvendor supply contract for a setting in which the periodicity of ordering is random.

Bassok and Anupindi (1997), Bassok et al. (1997), and Anupindi and Bassok (1998) analyze contracts of periodic purchasing commitment in a dyad comprised by a retailer and a supplier company that considered to be a producer. These works consider, respectively, the retailer selling a single product, a single product and flexibility in the quantity to be ordered, and multi-product and flexibility for the retailer's order. The contracts analyzed deal with a problem of a purchasing commitment for a finite multi-period planning horizon, in which uncertain demand is assumed when the retailer places orders periodically. Those authors address, basically, the allocation of the inventory risk between the companies, but the analysis of contract to determine the best purchase policy is centered on the retailer company. The retailer must anticipate the purchasing commitment cost, while the supplier does not participate in the decision process of the contract. So, the retailer wants to maximize his performance and does not consider the effect that his purchase decision would have on the supplier and, consequently, in the dyad.

The newsvendor model has been extensively used by Cachon (2003), for studying the coordination by several different contracts in a dyad formed by a single supplier selling to a single retailer, under the assumption of full information exchange among the companies. He starts by studying the general newsvendor model faced by the retailer and continues extending it in several

directions, such as: allowing the retailer to choose his retail price (in addition to his stocking quantity) or exert costly efforts to increase demand, considering models with more than one replenishment opportunity, incorporating the supplier's actions in the study of a single location base stock model by making the supplier to keep inventory at a holding cost lower than the retailer, and extending the number of participants from a dyad to a supplier with multiple competing retailers. He also relaxes the full information assumption and concludes, under asymmetric private information, under which the accurate sharing of information is necessary for achieving supply chain coordination by implementating the companies' optimal actions.

The retailer's purchasing decisions can also be assisted by a capacity reservation contract. Jain and Silver (1995) and Costa and Silver (1996) analyze a type of contract for assisting purchase decisions that consider the possibility of reserving capacity by paying a premium price to the supplier company. In the purchasing problem treated by those authors, two types of uncertainties are considered, namely: the uncertainty in the product demand and the uncertainty in the supplier company's capacity. Jain and Silver (1995) deal with these uncertainties as continuous random variables in a single-period purchasing problem, which is treated as a problem of retailer's profit maximization. Costa and Silver (1996) deal with these uncertainties as discrete random variables for a multi-period purchasing problem of retailer's cost minimization. The incorporation of uncertainty in the supplier's capacity impacts the analysis of the contract considerably because the dependence of the retailer's decision from the available supplier's capacity leads to more complex models to be solved.

The general case studied by Jain and Silver (1995) considers the market demand represented by a continuous probability function and the cost to reserve capacity defined by a strictly increasing convex function. Due to the existence of multiple optimal solutions, Jain and Silver (1995) determine conditions that must be met by a feasible solution to be an optimal solution. The authors develop a solution approach, and an algorithm, for finding the best dedicated capacity level when the market demand is represented by a Normal probability-density function and the capacity reservation cost is defined by a linear function. Costa and Silver (1996) develop several resolution procedures including heuristic algorithms and an exact method, which is controlled by a Branch and Bound procedure based on dynamic programming. Because the exact method's complexity is of exponential order, it is applicable only to problems of relatively small size. However, according to the computational results, the heuristic procedures provide good approximate strategies and

require considerably less computational effort than the exact procedure.

2.2 Analysis of contracts centered on the performance of a dyad

The analysis of contracts centered on the performance of a dyad usually have two goals, namely: the dyad coordination level that can be achieved by the contract and the possibility of arbitrary allocating to each company part of the dyad's gain derived from the contract. A contract can be considered coordinating if the optimal joint actions under the contract result in a Nash equilibrium, that is, none company gains by departing from the set of optimal actions for the dyad (Cachon, 2003). In the contract analysis focused on the dyad's performance, the flexibility in allocating gains through the adjustment in the contract parameters is key to its applicability because there is no control by any one of the parties over the other. However, the actual distribution depends on the bargaining power of the companies at the moment of negotiating the contract parameters.

The modeling required to carry out the analysis of contracts is tightly dependent on the manufacturing setting to be studied, and variations in its characterization can lead to considerably different models. The interdependence between the assumptions made and results obtained may be so complex and strong that it may be difficult to relax them and retain some desirable results obtained. This means that, in isolation, the features of a contract and its setting does not say much about the contract's nature, making a general and meaningful typology. So, the papers directly related to the problem addressed in this dissertation have been classified according to: (i) some aspects of the manufacturing setting under study, such as: types of companies and existence of alternative markets (i.e. the possibility of the contracting companies to trade with others that do not participate in the contract), (ii) the assumptions considered in modeling, which are basically two, namely: type of information (symmetrical or asymmetrical) and compliance regime (voluntary or forced), and (iii) the issues being investigated in the analysis of contracts, i.e. dyad coordination level and flexibility of benefit allocation.

In what follows, the papers that approach the analysis of contracts centered on the dyad's performance are commented in terms of the above aspects mentioned. The taxonomic classification is summarized in Table 2.1.

In the coordination contract literature, it is rare to find works that deal with contracts where both companies in the dyad are manufacturers deciding their capacities with probabilistic demand information. Schneeweiss et al. (2004) consider two manufacturers who must decide about their capacities,

and they study two types of multi-period contracts of purchasing commitment without recourse and without trading with the market. Jin and Wu (2007), Erkoc and Wu (2005) and Cachon and Lariviere (2001) study a dyad comprised by two "manufacturers", but the buyer company is not actually a manufacturer as it makes no medium-term capacity decision. In these works, the buyer reserves part of the supplier's capacity, or makes purchasing decisions in advance by order commitments that guarantee the supply of the critical input for his production process. Serel et al. (2001), van Delft and Vial (2001), Cachon (2004), Cachon and Lariviere (2005) and Özer and Wei (2006) analyze contracts in a dyad formed by a retailer and a manufacturer supplier, in which the contracts are analyzed to assist the retailer's purchasing decisions.

The consideration of alternative markets for the companies as, for example, the spot market or other companies, allows the evaluatin of the impact of the contract being analyzed under competitive pressures. Serel et al. (2001) explore a capacity reservation contract in a manufacturing setting in which the retailer has the spot market as an alternative supply source, while the supplier company is completely dedicated to him. Jin and Wu (2007) treat the coordination of expansion of a manufacturer supplier via a capacity reservation contract in the high-tech industry. The setting studied by them considers a single supplier and alternative customers for the supplier, but at lower profit rate. Furthermore, no customer is a manufacturer in the terms considered here because they have no medium-term capacity limitation. The other works found do not consider alternative markets for none of the companies, that is, the dyad is considered as an economically closed system where the supplier is the sole source of material.

Most of the papers that aim at achieving dyadic coordination assume symmetric information with respect to market demand and the cost, or profit parameters, as well as a forced compliance regime. Schneeweiss et al. (2004) and van Delft and Vial (2001) consider asymmetrical information between the companies. But, Schneeweiss et al. (2004) assume the existence of an external agent that plays the role of a central evaluator that optimizes the dyad's performance from the companies' individual performances, while van Delft and Vial (2001) consider that the supplier is able of screening the buyer's information by his order commitments. Serel et al. (2001), Cachon (2004), Cachon and Lariviere (2005), Jin and Wu (2007) and Erkoc and Wu (2005), full information flow is considered between the companies. Cachon and Lariviere (2001) and Özer and Wei (2006) relaxed the symmetrical information assumption and treat the problem of how to share demand forecasts by contracting.

The forced compliance assumption is considered explicitly by some authors, while only in an implicit way by others. Actually, the forced compliance must be demanded when it is the buyer who offers the contract, even so the analysis of the contract is centered in the dyad (i.e. the contract could be agreed if the supplier is not worse off). Since the works developed by van Delft and Vial (2001), and Jin and Wu (2007) consider that it is the supplier who offers the contract, they assume voluntary compliance regime. Schneeweiss et al. (2004), Serel et al. (2001), Cachon (2004), Cachon and Lariviere (2005), and Özer and Wei (2006) consider implicitly that the supplier would build sufficient capacity to always satisfy the buyer's full order-commitment. Erkoc and Wu (2005) and Cachon and Lariviere (2001) relax the forced compliance assumption and evaluate the impact that this would have on the dyad's performance.

In the analysis of the contracts proposed by Schneeweiss et al. (2004), van Delft and Vial (2001) and Serel et al. (2001), the purpose is to evaluate the individual performance improvement of each company and, consequently, the dyad's performance improvement, rather than to achieve dyad coordination with 100% efficiency level. In fact, the asymmetrical information assumption is often an impediment to achieve full dyad coordination. The dyad coordination and arbitrary allocation are addressed by Cachon (2004), Cachon and Lariviere (2005), Jin and Wu (2007), Erkoc and Wu (2005), Cachon and Lariviere (2001), and Özer and Wei (2006).

Finally, the mechanism to be followed for defining the terms of the contract between the companies, i.e. the parameter values accepted by both parties is an issue that is not satisfactorily treated in the literature. That mechanism can be a iteractive negotiation process carried out with negotiators of both companies (see, for example, Dudek and Stadler, 2005, and Özer and Wei, 2006). An alternative is the selection of a contract out of a set offered by one of the companies, which can be the one more informed if it is possible to define a signaling process or the one less informed if it is possible to define a screening process. Another alternative is a contract offered as a take-it-or-leave-it offer that is often modeled as a Stackelberg game, in which the companies have symmetric information about each other (Özer and Wei, 2006). The contracts analyzed by van Delft and Vial (2001), Jin and Wu (2007), and Özer and Wei (2006) are offered by the supplier, while the contract analyzed by Cachon and Lariviere (2001) is offered by the buyer. The authors of other papers commented above, that is, Schneeweiss et al. (2004), Serel et al. (2001), Cachon (2004), Cachon and Lariviere (2005), and Erkoc and Wu (2005) do not comment on the mechanism to be used by the parties to arrive at the

optimal, or some acceptable contract. The cited authors assume the existence of an external agent, or central evaluator, who knows the companies' individual performances to assess the joint performance of them, i.e. dyad performance for each given contract.

2.2.1 Types of contracts - A brief presentation

The push and pull contracts are defined by a single wholesale price and, through the contracts, the dyad's inventory risk is borne by only one of the two companies. The retailer places his order for his entire requirement before the selling season. Under the push contracts, he pays when he places the order, while he replenishes and pays as needed during the season under a pull contract. So, the inventory risk is held only by the buyer under the push contracts or only by the supplier under the pull ones. The advance purchase discount contracts are defined by two wholesale prices, a discount price for inventory purchased before the season (i.e. prior to the supplier's capacity decision), and a regular price for replenishments during the selling season. So, that type of contract allows intermediate allocations of inventory risk shifting the excess of inventory risk from the supplier to the buyer (Cachon, 2004). In fact, the retailer bears the risk on inventory ordered before the season, while the supplier bears the risk on any production in excess of that amount ordered.

Buy-back contracts are essentially push contracts that consider the possibility of returning to the supplier some amount of product not sold during the season. The retailer may return some unsold product to the supplier for only partial credit (Tsay et al., 2002). In revenue-sharing contracts, the retailer pays a wholesale price for each unit purchased from the supplier company plus a percentage of the revenue that he generates. For that contract to be a coordinating-contract, it is required that the wholesale price is less than the supplier's production cost (Cachon and Lariviere, 2005). Consequently, the supplier loses money in selling the product and only gains by participating in the retailer's revenue.

The contracts based on capacity reservation involve a delivery commitment by the supplier and a payment commitment by the buyer. The supplier guarantees to deliver any amount of the order placed by the buyer up to the reserved capacity and, in exchange, the buyer offers guaranteed payment (Serel et al., 2001). The buyer pays a reservation fee to the supplier, according to a function in terms of the units of capacity to be reserved (Özer and Wei, 2006), for which forced compliance for the supplier is assumed (i.e. she will really build the capacity reserved by the buyer). Under some manufacturer

Author(s)	Type of contract	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Schneeweiss et al.	B-contract	B:M	–	AI:MD,CP	FC	I	V	–
(2004)	M-contract	S:M	–	AI:MD,CP	FC	I	V	
van Delft and Vial	Advance Purchase	B:R	–	AI:MD	VC	I	V	CO
(2003)	with options	S:M	–					
Serel et al.	Capacity reservation	B:R	B	SI:MD,CP	FC	I	V	–
(2001)		S:M						
Cachon	Push/Pull	B:R	–	SI:MD,CP	FC	I	V	–
(2004)	Advance Purchase	S:M		SI:MD,CP	FC	E	A	
Cachon and Lariviere	Revenue-Sharing	B:R	–	SI:MD,PR	FC	E	A	–
(2005)	Buy-back	S:M		SI:MD,PR	FC	E	A	–
Jin and Wu	DR	B:M*	S	SI:MD,CP	VC	E	V	CO
(2007)	Take-or-pay	S:M		SI:MD,CP	VC	E	V	
Erkoc and Wu	Fully DR	B:M*	–	SI:MD,PR	FC	E	–	–
(2005)	Partially DR	S:M		SI:MD,PR	FC	E	A	
	Cost-Sharing			SI:MD,PR	FC	E	A	
Cachon and Lariviere	Advance Purchase	B:M*	–	SI:MD	FC	E	V	CO
(2001)	plus options	S:M		SI:MD	VC	I	V	
				AI:MD	FC	E	V	
				AI:MD	VC	I	V	
Özer and Wei	Capacity reservation	B:R	–	SI:MD	FC	E	A	CO
(2006)		S:M		AI:MD	FC	I	–	
	Advance Purchase			SI:MD	FC	E	V	
				AI:MD	FC	I	–	
	Pay-back			SI:MD	FC	E	A	
				AI:MD	FC	E	A	

* The company is said to be manufacturer, but the capacity decision is not addressed.
(1) Type of company: retailer (R) (can also be a distributor) or manufacturer (M).
(2) Supply/Customer alternative markets for the buyer/supplier (B/S), or for none (–).
(3) Symmetric/Asymmetric information (SI/AI) about MD (market demand), CP (cost parameters) or PR (profit rates).
(4) Compliance regime for the supplier: forced compliance (FC) or voluntary compliance (VC).
(5) Dyad coordination: improvement (I) or efficiency (E).
(6) Allocation of the dyad gain by the contract: various (V) or arbitrary (A).
(7) Mechanism proposed to determine the contract to be agreed: none (–) or contract offered (CO).

Table 2.1: A taxonomic classification of the papers approaching analysis of contracts focused on the dyad performance.

settings, the forced compliance assumption is necessary for reaching coordination among the companies. In general, under a capacity reservation contract, the buyer ensures his supply and, under some settings, a reduction in the costs for the input supplied. Despite the fact that most of the supplier's benefits under the capacity reservation contract is not explicitly quantifiable, except under the manufacturer settings in which the capacity investment is expensive (Jin and Wu, 2007, and Erkoc and Wu, 2005), among the main ones are the reduction in the necessity to find new customers, smoother future cash flows, and diminution in the variance of the buyer's orders (Lee et al., 1997).

There are several types of contract based on capacity reservation, such as DR (deductible reservation) contract (which can be full or partially) (Jin and Wu, 2007; Erkoc and Wu, 2005), pay-back contract (Özer and Wei, 2006), take-or-pay contract (Jin and Wu, 2007) and cost-sharing contract (Erkoc and Wu, 2005). Under the fully DR contract, the buyer pays up front for the entire reserved capacity and, when his firm order is placed, only the ordered units of reserved capacity are deducted from the final payment. So, the supplier receives full compensation for the capacity she has built but was not used by the buyer, thus reducing the variance of her profit. In particular, in the settings of costly capacity expansion, the DR contract reduces the supplier's capacity risk, while preserving flexibility in the reservation fee and committed expansion amount (Jin and Wu, 2007). The end effect is to encourage the supplier to expand her capacity. An alternative to that contract is the partially DR contract. In this variant there is a refund rate for each unit of capacity not utilized by the buyer, that is, the buyer's payment associated to the capacity he did not use is not completely lost by him (Erkoc and Wu, 2005). The added dimension in the partially DR, that is, the refund rate, enables the supplier company to have more flexibility in setting the reservation fee.

In pay-back contracts, too, the buyer compensates the supplier for the entire unused capacity that he had reserved, whose payment is usually carried out up front for the entire reserved capacity (Özer and Wei, 2006). The take-or-pay contract can be considered as a variation to the pay-back contract, in which the buyer does not pay up front for the capacity reservation neither pays for a pre-fixed quantity of the units of non-ordered reserved capacity (Jin and Wu, 2007). That is, the buyer only pays a penalty rate for the part of unused capacity, rather than for the totality of it as under the pay-back contract. Thus, a take-or-pay contract is equivalent to a pay-back contract with quantity flexibility. Note that, if the reservation fee in the DR contract is equal to the penalty rate in the take-or-pay contract, there is no flexibility in the quantity. And if the effect of the different cash flows is compensated, then the DR

contract is equivalent to the take-or-pay contract. In the context of capacity reservation contracts, the cost-sharing contracts consider the reservation fee over the cost for the entire capacity to be reserved, rather the per-unit one. In particular, when the capacity cost is considered to be linear, the partially DR contract is equivalent to the cost-sharing contract (Erkoc and Wu, 2005).

2.2.2 Analysis of contracts focused on the dyad improvement

Schneeweiss et al. (2004)

Schneeweiss et al. present an approach to analyze contracts in order to coordinate multi-period planning decisions in the dyad and, also, to obtain the optimal contracts taking into account the operational consequences, which must be anticipated in the medium-term. Under the contract conditions, the buyer and supplier companies agree to hold their individual private information and autonomy in their decision processes. In the models, the demand at each planning period is assumed to be deterministic for the entire planning horizon, even though an analysis is developed by means of Monte Carlo simulation for assessing the results under random market demands. Two types of contracts, the M-contract and B-contract, are analyzed in terms of the impact that they have on the companies' operational performances. The M-contract considers a total order/delivery commitment for the entire planning horizon, while the B-contract is designing for the just-in-time operational coordination at each period and is based on an incentive (bonus) paid by the buyer for each period that the quantity delivered by the supplier matches his material order. Thus, those contracts involve aspects of medium-term capacity planning and short-term production planning, and an unidirectional hierarchical relationship arises between the buyer and supplier, which is carried out in two stages: (i) the buyer provides information to the supplier about his likely material requirements in the medium-term, according to the demand market forecast, and (ii) the buyer informs the supplier about his material order to be required for the short-term schedule, according to a realization for multi-period market demand. Finally, the supplier delivers the material required satisfying the buyer's order partially, or completely. Since both companies are manufacturers, in the first stage, each company decides on its medium-term production capacity based on the demand forecast. Then, in the second stage, each company can adjust the capacity decided previously, according to its short-term possibilities, and decide its firm order for the purchase of inputs. For each contract, the companies' profits are determined in terms of the contract parameters and demand realization. By means of Monte Carlo simulation, the expected profit

of each company and, hence, the dyad's expected profit can be determined. So, it is possible to obtain the parameter that optimizes the dyad's profit, as well as the range of values for the parameter that lead to each company to be better off under each contract analyzed.

van Delft and Vial (2003)

van Delft and Vial propose a stochastic programming approach for the quantitative analysis of supply contracts that involve flexibility through periodic commitment by options in a multi-period planning horizon. The contract problem focuses on the supplier, who offers several options contracts to the buyer, and the market demand is considered to be correlated among the periods. Each option is characterized by the unit price of sale, option and exercise, and the bounds for the amount of options that can be exercised in each period. The market demand is assumed to be stochastic and the demands among the periods are considered correlated, which is explicitly incorporated in the modeling. Since the demands are correlated, the state and decision variables are considered to be stochastic too. In the analysis of contract, the buyer solves his problem of the quantity to be produced, taking into account the contracts offered, and places orders and options that maximize his expected profit. That information is considered as demand functions by the supplier, who must solve the contract problem in order to get the optimal contract parameters. Consequently, she determines the optimal quantity to be produced to serve to the buyer and/or stock to be used in a future period. An important assumption in solving the contract problem considers that the supplier is able to reconstruct the buyer's optimal policy and, thus, to determine his market demand over the same tree of events that was used by the buyer. Under this assumption, the analysis of contract does not need an external agent that knows the evaluation of the contract in each company, because the buyer's decision variables are parameters in the supplier model. Despite of defining a mechanism to determine a sub-optimal contract for the dyad, which is based on the companies' direct participation, the reconstruction assumption could be difficult to be actually satisfied and, consequently, to restrict its application.

Serel et al. (2001)

In the study made by Serel et al., the buyer company can choose between a long-term contract based on capacity reservation with the dedicated supplier and short-term contracts with supplies in the spot market. The inclusion of market suppliers forces both companies to evaluate the viability of the capacity reservation contract under competitive pressures. It is important to stress that they consider symmetric information about the demand distribution and cost

parameters, and the wholesale price to the charged by the supplier company is the primary contract parameter. The models are developed for a multi-period planning horizon, but those authors assume independence of the demand between the periods. In the setting considered, the probabilistic demand is assumed stationary in an infinite horizon, the capacity commitment level is the same for all the periods, and the unused capacity can not be sold to the other customers and does not have value for the buyer nor supplier. The rational actions for the two companies are investigated under two different types of periodic review inventory control policies used by the buyer company, namely: the two-number policy (which is studied by Hening et al., 1997) and the base stock policy. The computational results show the system's expected profit remains reasonably stable under the inventory control policies studied. But, it is reasonable to choose the base stock policy, a well-known and widely used policy in the practice. On the other hand, an exclusive relationship between the buyer and dedicated supplier requires a considerably higher capacity to be reserved in comparison to the retailer's possibility of using both supply sources, dedicated supplier and the market suppliers. Thus, in the presence of a spot market, supplying from a unique supplier could not be a practical alternative. In fact, they find a range of values for the unit capacity cost over which the buyer's optimal base-stock policy includes buying from the dedicated supplier and others in the market. The threshold for which the buyer would have an exclusive relationship with the dedicated supplier is independent of the random demand per period and depends on the holding and shortage costs per unit and the market prices.

2.2.3 Analysis of contracts focused on the dyad coordination

Cachon (2004)

Cachon studies the impact that simple contracts, such as: pull, push and advance purchase contracts, have on the efficiency of the supply chain. Those contracts are designed to allocate the inventory risk between the companies. The retailer and the supplier company are assumed to be risk-neutral. The retailer sells a product over a single selling season at a given price and the units remaining at the end of the season are salvaged at a price per unit that is less than the supplier's production cost, independent of which company salvages the unit. The demand during the selling season is stochastic and represented by a distribution with the IGFR property (strictly increasing generalized failure rate). In the study, the Pareto set of contracts are determined, for each type of contract (pull and push), that is, the range of values for the quantity to be

produced such that the type of contract is Pareto. A contract is considered Pareto if there is no other contract such that none company is worse off and some of them is strictly better off. When only one type of contract is considered, it is found that the pull contract is more attractive than the push one from the point of view of the supply chain, i.e. the retailer prefers to not pre-book inventory and depends on the supplier's production for at-once orders. The profit in supply chain is higher, under the pull contract, despite of the inventory to be greater, which is maintained in the supplier company. Also, in relation to the allocation of the profit, the retailer's maximum profit with the pull contract is greater than the supplier's maximum profit with the push contract. However, the Pareto set that considers both types of contract (the pull and push contracts) includes those contracts of each type whose amount to be produced is more or equal than the amount for which the companies are indifferent to the type of contract. In particular, the push contract preferred by the supplier is Pareto inferior and may even be Pareto dominated by the pull contract, but neither allocation of inventory risk dominates the other since both contracts are in the Pareto set. Furthermore, the Pareto set that considers push, pull and advance-purchase discount contracts includes the ones of the last type such that the at-once order price is equal to the retailer price (i.e. the retailer gains nothing for the units non-prebook), and the prebook order price is between the supplier's production cost and retailer price. The dyad coordination is reached and any division of the supply chain's profit is achievable with the Pareto subset of the advance-purchase discount contracts, which are simpler to manage that the buy-backs or revenue-sharing contracts. Nevertheless, the advance-purchase discount contracts no longer coordinate the dyad under the following situations: (i) there are additional shipping and handling costs for at-once orders, (ii) the retailer exerts costly effort to increase the sales, and (iii) inventory risk is considered in at-once orders due to residual uncertainty. In each one of those situations, the push contract becomes relatively more attractive than the pull contract.

Cachon and Lariviere (2005)

Cachon and Lariviere consider two companies forming the dyad, the retailer and the supplier company, to be risk-neutral, and it is assumed that to monitor the retailer company's revenue is costless. The retailer purchases an asset from the supplier company at the beginning of the selling season, which is exogenously specified, and he is the unique company that generates revenue in the supply chain from rentals or outright sales. In the modeling, the demand can be represented deterministically, or stochastically, and the

supplier company selling to a classical fixed-price newsvendor, or a price-setting newsvendor in which the retailer must decide about the quantity to be purchased and the price to be paid (i.e. the retailer chooses optimal price and quantity). It is demonstrated that, under price-setting newsvendor, the revenue-sharing contract coordinates a supply chain with a single retailer and arbitrarily allocates the dyad's profit. The coordination of the dyad being studied too can be achievable by the buy-back, quantity-flexibility and sales-rebate contracts, but in the fixed-price newsvendor case. Also, price-discount contracts that have both terms of the contract, wholesale price and buy-back rate, are conditioned on the chosen retail price to coordinate the supply chain under the price-setting newsvendor (Bernstein and Federgruen, 2005, apud Cachon and Lariviere, 2005). In particular, the authors have shown that the revenue-sharing and buy-back contracts are equivalent under the fixed-price newsvendor case, while the revenue-sharing and price-discount contracts are equivalent under the price-setting newsvendor case, where the equivalence is in the sense of generating the same cash flows for any realization of demand. Furthermore, since the set of coordinating contracts is independent of the revenue function, that result is extended to the setting that includes quantity-competing retailers that have the same marginal cost, that is, the revenue of each retailer depends on its own quantity as well as the other retailer's quantities rather than price (fixed-price newsvendor). Nevertheless, the revenue-sharing contract generally does not coordinate competing retailers, under the price-setting newsvendor case, when revenue of each retailer depends on the other retailers' actions. In addition, the revenue-sharing contract does not coordinate a supply chain with demand that depends on costly retail effort, but the supplier company may still choose to implement that contract if the impact of sale effort is sufficiently small. Since the verification of the retailer's revenue is required for the implementation of the revenue-sharing contract, an administrative issue arises for considering this contract in other industries. In particular, there are situations in which the revenue-sharing contract provides only a small improvement over the administratively cheaper wholesale price contract.

Jin and Wu (2007)

In the characteristic setting of the high-tech industry, Jin and Wu consider the supplier company to be a manufacturer that faces considerable risk to expand his capacity above the level of reserved capacity that is decided by the buyer company that is a manufacturer company too and does not have alternative supply sources. The optimization models are formulated for

single-period profit maximization problems, for which the profit rates are directly used. The information about the market demand forecast and profit rates are considered to be symmetric information, but the real demand is assumed as private information. The reserved capacity by the contract has zero salvage value by the supplier company and, even so, she has alternative customers out side the dyad, the profit rate is lower than for the ones that participate in the system. The authors propose a DR contract defined by two parameters, namely: the reservation fee and the capacity expansion level, where that level defines the capacity to be built over the reserved capacity at the reservation fee value. The buyer company decides the capacity level to be reserved at the reservation fee according to the set of contracts offered by the supplier company. It is arisen a trade-off between companies, due to the contract parameters are directly proportional (i.e. to higher reservation fee, higher expansion of capacity by the supplier) and the reserved capacity level and the reservation fee are indirectly proportional (i.e. to higher reservation fee, lower reserved capacity by the buyer). It is demonstrated that the DR contract with excess of capacity is individually rational for both companies, that is, none them is worse off under the contract conditions and, also, the dyad coordination is reached. The DR contract proposed is more general than a take-or-pay contract defined for the similarly considering the level of capacity excess as one of their parameters. In fact, if the difference on the cash flow is ignored, the reservation and penalty fees are considered equal, and no flexibility is incorporated, then the DR and take-or-pay contracts defined for modeling the capacity excess are equivalent. Nevertheless, the take-or-pay contract is not always individually rational for the companies and the dyad coordination is only reached when the capacity excess parameter is equal to zero, that is, the triplet take-or-pay contract considered degenerates in a two-parameter contract. The authors extend the analysis of the system adding another buyer company, where the two buyers are assumed to have the same profit rates but each one of them faces a different demand distribution function. The interaction between the buyers remains a Stackelberg game, while the reservation competition between them is modeled using a Nash game, for which there is a unique equilibrium and, thus, the manufacturer supplier is able to choose finally, taking into account the buyers' decisions, the contract parameters to achieve the dyad coordination.

Erkoc and Wu (2005)

Erkoc and Wu treat the problem of capacity risk that a manufacturer supplier in the high-tech industry faces to expand the so called "soft capacity"

(which does not consider capital investment) under DR contract with fully payment, partially DR contract and cost-sharing contract. In this work, the expansion of capacity is considered in the capacity reservation level that is the buyer company's decision, that level allows her to expand the capacity more aggressively. Under the manufacturer setting studied in this paper, the buyer company does not have alternative supply source neither the supplier company alternative customer. It is considered full information between the companies, specifically, in relation to demand distributions as well as the revenue and cost parameters, and, also, forced compliance for the supplier company is assumed. The single-period optimization models are formulated by profit maximization problems in which the capacity cost is considered as a convex function, due to the expansion of the soft capacity treated demonstrates diseconomy of scale. The results show the fully DR contract coordinates the companies only if the reserved capacity by the buyer is equal to the integrated system's capacity decision (that system correspond to the central planning entity), but this contract is beneficial to both companies. The partially DR and cost-sharing contract allow the dyad coordination in the setting described and, also, different allocations of the system surplus derived by the contract. Furthermore, when the capacity cost is considered to be linear, those two contracts are equivalent. Also, it is carried out an analysis relaxing, ceteris paribus, the assumptions of convex capacity cost, forced compliance for the supplier company and fully updated demand. When the capacity cost is linear, it is observed that the reservation fee and the supplier company's surplus are independent of the market size, which could be explained by a balance between the increase in the capacity cost, due to the market size, and the reduction in the risk. However, when the capacity cost is convex, the reduction in risk is not sufficient to justify the increase in the capacity cost. The forced compliance assumption can be relaxed incorporating a non-compliance penalty paid by the supplier company. Since the buyer company can reserve less than the optimal capacity, the supplier company has an incentive to set that penalty sufficiently large so as to induce the buyer to behave as in the forced compliance. If the buyer company has to place the firm order before the demand uncertainty is completely resolved, the dyad coordination could not be achieved under the types of contracts analyzed under the fully updated information assumption. Nevertheless, adding a determined buy-back price to the capacity reservation contract, the dyad coordination is reestablished.

2.2.4 Analysis of contracts relaxing relevant assumptions

Cachon and Lariviere (2001)

Cachon and Lariviere study the problem of how demand forecasts can be shared in an environment in which truthful information can not be exchanged, due to the incentive from the buyer company that acts as a leader (i.e. who offers the contract). Also, it is analyzed what impact the compliance regimes for the supplier company, forced and voluntary, has in the dyad performance. They propose a contract that includes firm order and options in order to assure the supply for a critical component from a sole supplier company, so it addresses his purchase decision rather than his capacity decision. Both autonomous companies forming the dyad are assumed to be risk neutral. The buyer faces stochastic demand for his single product and, in the study, two situations are considered, high and low demand forecast. Thus, it is assumed implicitly the buyer has built sufficient capacity to produce as much as the purchase decision for his critical component. So, the analysis of the contract is centered on the buyer, whereby is designed to lead the supplier to be not worse off and, in general, does not intend to be a coordinating-contract. In fact, the authors recall there is not any coordinating contract that includes firm commitment, because it possibly forces the companies to undertake actions that the integrated system (central planning entity) would avoid. For example, the integrated system never produces more than the realized demand, but the supplier would have to produce more than it, under forced compliance, if the buyer's firm order is higher than the demand observed.

Even under symmetric demand information, the buyer must anticipate the supplier's actions in designing a contract that maximizes his profit, because he does not know the supplier's cost information. The contract will be accepted by the supplier if it covers, at least, her opportunity cost, which is considered null for this setting because the component has no other function than as part of the buyer's product. Under the forced compliance regime, the supplier must build sufficient capacity to cover the buyer's maximum order stipulated in the contract agreed, which comprises by the firm order and options, and it is assumed the supplier's capacity does not exceed that order. While under the voluntary compliance regime, the supplier considers the buyer's order at the instance to make her capacity decision, but she is free to choose the capacity level below the maximum order. Under full information scenario and forced compliance, the dyad is coordinated if the buyer purchases only options at determined options and exercise prices, that is, no firm commitments exist. And, the buyer gains the integrated system's expected profit, while the

supplier company just recovers her opportunity cost. However, assuming full information about the supplier's cost and voluntary compliance, the buyer offers a contract at determined prices that lead to the supplier's capacity decision to be less than the integrated system's one, i.e. the dyad is not coordinated.

To study the impact of asymmetric information, it is assumed a separating equilibrium by which the buyer would offer different contracts for different demand forecasts. So, the supplier company learns the true demand forecast after observing the contract offered. Under forced compliance, if the buyer that faces a high demand forecast, he is able to offer a contract that coordinates the dyad with the same allocation of the system gain, that is, he earns the entire system's expected profit and the supplier is only not worse off. On the other hand, under voluntary compliance, the analysis becomes more complex, because the contract offered by the buyer must play two roles, namely: convincing the supplier that his forecast is true and inducing her to build adequate capacity. Now, for a buyer company that faces a high demand forecast, it is added the possibility of requiring capacity by firm commitments and/or a lump sum payment. In this situation, the capacity required by the optimal contract is higher that he desires, but it is less than the integrated system's capacity. In particular, if the optimal contract's firm order is less than the upper bound that ensures the supplier certainly builds some capacity, then the lump sum payment is not necessary (i.e. it is equal to zero). And, if the optimal contract offered includes firm order, then the corresponding capacity and wholesale price are both less than they would be if he could not offer firm commitments. Note that the lower price is an endogenous result for the contract proposed rather than an exogenous assumption and explicit condition of advance purchase contracts with discount per-unit for the firm order. Therefore, despite the firm commitments are not useful to aligning incentives between the companies, they are useful for communicating information. Particularly, firm commitments are undesirable because they could restrict the companies at the instance of final production decision when the demand information is revealed. The authors conclude that a buyer facing a high demand forecast has always interest to communicate it to the supplier, but sharing the forecast in a credible way can be costly, which is reflected by the lump sum payment.

Özer and Wei (2006)

Özer and Wei address directly the decentralized system's inefficiency problem derived from the information exchange between the two companies forming the dyad, which do not have alternative markets to trade the common component. For that, they analyze different types of contracts, such as: capacity reservation, advance purchase and pay-back, in order to determine the conditions under which it is possible to assure credible forecast information sharing, while the cost information sharing is implicitly involved in the contract. Thus, the contracts analyzed, under the asymmetric and symmetric information cases, are evaluated in terms of the effects that they have in the dyad coordination and profit sharing achieved in the system. The models are developed for single-period horizon planning and the market demand is represented by a continuous random variable. Two types of uncertainty are considered, namely: (i) the market's residual one, which is considered zero-mean continuous random variable, and (ii) the demand forecast one, which is assumed to be deterministically known by the buyer and as a limited range, zero-mean continuous random variable for the supplier. So, the buyer is assumed to be the company more informed in relation to the demand forecast.

In the analysis of the capacity reservation contract, it is assumed the "revelation principle" (Fudenberg and Tirole, 1991, apud Özer and Wei, 2006), whereby the supplier is enabled to offer a limited optimal menu of contracts to the buyer for guaranteeing his participation, while the buyer finally reveals the truthful information by the contract chosen. Under symmetric information and linear capacity reservation cost, the capacity reservation contract allows the achievement of the dyad coordination and different allocations of the system surplus. The analysis of the advance purchase contract is modeled by a signaling game in order to the buyer reveals its information in a credible way. It is assumed the so called "separating equilibrium", which establishes that different demand forecast uncertainties lead to different advance purchase quantity, so the supplier really learns the buyer's private information from the advance purchase order. Under asymmetric information, the buyer can communicate his forecast information in a credible manner by the advance purchase contract, but the dyad coordination is not reached. Also, under symmetric information, the buyer company takes advantage of the discount because the contract price is less than the wholesale price.

The pay-back contract with penalty per unit of unused capacity less than the cost of capacity reservation leads to the dyad coordination under symmetric information about the buyer's forecast and, also, the arbitrary distribution of the system surplus is feasible. So, the authors propose to combine the advance

purchase and pay-back contracts with the purpose of achieving the dyad coordination under asymmetric information, which is possible if the wholesale price is equal to the advance purchase price. Note that, for that price situation, the combination of those contracts is essentially equivalent to have a wholesale price contract with a pay-back agreement, whose parameter is determined under symmetric information. Therefore, when the buyer's forecast information is private, the part of the advance purchase contract has a strategic role that enables the buyer to reveal his forecast credibility to the supplier. Finally, the numerical results show that the degree of forecast information asymmetry between the companies and the risk-adjusted profit margin (i.e. the ratio of the profit to the market residual uncertainty) are two important drivers to determine the dyad efficiency and which type of contract to be selected.

2.3 Analysis of the contract proposed in this dissertation

This work is focused on the coordination, by a supply contract, of tactical (medium-term) decisions of two companies who are free to trade their products in the market at given market prices. In contrast with the usual assumption in the literature, both companies are considered to be autonomous manufacturers implying finite production capacity at each one, and the need to adjust them before demand is actually known. A contract capacity reservation with reward-and-penalty is proposed to promote the coordination of the companies' medium-term capacity decisions (see details in Section 3.4). The companies must decide on their capacities in advance of the demand realization and, in the case of manufacturer companies, the medium-term capacity decisions will limit their production in the short-term. This last aspect is an important difference between manufacturer-to-retailer relationships and manufacturer-to-manufacturer relationships. Indeed, in the short-term, a retailer, or distributor, can buy in the spot market as necessary according to the actual demand.

The analysis of the contract is centered on the dyad's performance, rather than on the benefit for a single company. It is assumed that both companies must be better off under the contract than acting independently in the market, i.e. the contract must be viable (or desirable) for both companies because there is no dominant company. It is considered that market demand forecast for a product known only for the company that sells it, the cost are private information to each company and forced compliance regime is assumed for the supplier. To evaluate the dyad's performance under the contract its performance will be compared to the ones without the contract, and under central planning. Similar to the papers presented in this chapter (except for

the ones in which one company offers the contract to the other) the mechanism to be used by the companies for arriving at a contract acceptable by both will not be treated here.

According to the description of the types of contract presented above, the contract proposed is equivalent to the capacity reservation contract treated by Serel et al. (2001). And, without considering the effect of the cash flow (i.e. if the amount to be paid to reserve capacity is made at the beginning or at the end of the single-period planning horizon), the capacity reservation with reward-and-penalty contract proposed is equivalent to the DR contract analyzed by Jin and Wu (2007), and to the pay-back contract studied by Özer and Wei (2006). Under DR and pay-back contracts, as well as under the contract here proposed, the supplier company receives compensation for the capacity she has built and has not been used by the buyer company.

Nevertheless, the manufacturing setting considered in this study, as well as the assumptions about the available information, differ from the ones considered in the three works above mentioned requiring different analyses. Indeed, in this work, both companies are considered to be manufacturer(s) deciding about their medium-term production capacities, while Serel et al. (2001) and Özer and Wei (2006) consider to the buyer company to be a retailer and the supplier company to be a manufacturer. Though of Jin and Wu (2007) consider two manufacturer companies, the downstream company faces the purchase commitment decision rather the medium-term capacity decision. In addition, both companies are assumed to trade in the market, so they have the spot market as alternative short-term source. Serel et al. (2001) consider the spot market as an alternative source only for the buyer, so the supplier is a company dedicated to the buyer. Jin and Wu (2007) consider the spot market as an alternative source only for the supplier, whereby the buyer is a exclusive customer for the supplier; and Özer and Wei (2006) consider no alternative source for the companies.

In relation to assumptions made in the analysis of a contract, in this study as well as in the one by Özer and Wei (2006), it is assumed asymmetric information about the market demand and cost, or profit, parameters, while both of them are assumed to be symmetric information by Serel et al. (2001) and Jin and Wu (2007). Since there is no dominant company, in this work as well as in the contract proposed by Serel et al. (2001), forced compliance is assumed for the supplier and, as mentioned above, the mechanism by which the companies would obtain an acceptable contract is not treated. In the studies carried out by Jin and Wu (2007) and Özer and Wei (2006) is considered the supplier offers a menu of contracts to the buyer, whereby the forced

compliance assumption is not required. In fact, Jin and Wu (2007) assume voluntary compliance for the supplier, while Özer and Wei (2006) consider forced compliance in order to analyze the effect that asymmetric information about the market demand would have on the dyad coordination and on the arbitrary allocation of the gain between the companies.