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### Conclusions

This dissertation addresses the problem of designing a contract for coordinating medium-term production capacities of two autonomous manufacturer companies engaged in a buyer-supplier relationship. Without any contract, each company trades independently its inputs and outputs in its respective perfect competition markets, at deterministically known market-given prices. It is also assumed that both companies can buy from the market as much of their inputs as necessary to maximize their profits. The companies face a limited random demand that is partially lost if there is not sufficient medium-term production capacity, while unused capacity and production surplus have no residual value, implying that in the short-term (when demand is deterministically known) no leftover inventory will be produced. At the instant of making their medium-term capacity decisions, the companies take into account their forecasts of market demand (represented by a continuous probability distribution), selling prices and production costs in order to maximize their own expected profits. Considering the gain of efficiency that the dyad can derive from coordination, and the strategic advantage of remaining autonomous in their decisions, in this research a type of supply contract has been designed to coordinate the single-period medium-term capacity decisions of the companies under probabilistic market demands.

The coordinating contract designed is a capacity reservation contract with reward-and-penalty. It establishes a quantity that corresponds to a purchase commitment by the buyer company, and a capacity reservation for the supplier company. Under the contract each manufacturer will decide its capacity in the medium-term when they know their demands only probabilistically. In the short-term, when actual demands are revealed, each manufacturer will produce a quantity that maximizes its own short-term profit taking into account the capacity constraint imposed by its own medium-term decision and the contract parameters. The contract parameters are the purchase-commitment/capacity-reservation quantity, a per-unit discount that the supplier will grant to the buyer for each unit it orders up to the committed quantity, and a penalty that the supplier will charge the buyer for each unit short

of the committed quantity, if the buyer orders less than committed. The incentive each party may have for signing the contract is clear. For the buyer it is interesting because it may reduce its input cost, and for the supplier because its demand is augmented with less risk because part of the capacity cost will be covered by the forfeit penalty. However the possibility of both parties being better-off with the contract, and how much so, is not so clear. The objective of the analyses that constitutes the kernel of the dissertation has sought answers to these questions.

The analysis of the contract has been made to investigate the two first issues stressed by Cachon (2003), namely: the degree of coordination between the companies that can be achieved by the contract, and how arbitrary can be the distribution of the gain that the contract produces. The relevance of the first issue is obvious, and it can be tackled by determining how close the total buyer-supplier dyad's expected profit under the contract can be to the ideal maximum profit. Of course only viable contracts are of interest, that is, the contract must simultaneously improve the performance of each company as compared to the situation without contract. The second issue is relevant because the contract must be accepted by both parties, and hence there must be room for negotiation. The exploration of the second issue is more involved. A contract can produce full coordination, i.e. produce the maximum ideal profit, but only for certain partitions of the total gain of the dyad, or it can allow a wide range of distribution (perhaps completely arbitrary) for this optimal total gain. It is also possible that a contract is capable of producing a wide range of distributions, but not necessarily with full coordination.

The third issue stressed by Cachon is that a contract must be amenable for actual implementation. This has been only partially explored in this work. The viability of implementation was considered from the point of view of the interest that the companies would have in considering the contract proposed. But, like other studies in the literature, this analysis was made under assumptions that may preclude implementation. A deep exploration of this issue would require the comparison of the proposed contract with other contracts that may be adapted for the manufacturing setting considered. It is clear that the proposed contract can be equivalent to some other forms of contract such as a fully DR (deductible reservation) contract, or a pay-back contract. Specifically, credible information and forced compliance regime are, perhaps, the most delicate aspects of this third issue.

The proposed contract rests on the assumption that the buyer company will inform its true expectations on the size of the company order it will end up putting. In this dissertation it has been argued that, according to

the characteristics of the contract, if the buyer distorts this information the supplier may be hurt, but he will gain nothing and, hence, has no reason for misinforming. However, is that enough for making his information credible to the supplier? Concerning compliance, even under the threat of very hard legal consequences, the supplier may have an economic advantage by reserving somewhat less capacity than stated in the contract. This is easily seen from the fact that, beyond a certain level, the probability of the buyer's order exceeding the available capacity level can become very small, and hence the risk may be negligible. In addition it may be difficult, even a posteriori, for the buyer to verify if the agreed capacity has in fact been reserved.

Also, similar to other previous studies, the negotiation process by which the companies will determine the contract that would be agreed has not been treated in this research. It is an issue that involves strategic aspects and depends on specificities of each case. For instance, it may happen that, though costs and demand forecasts are held as private information, one party may approximate them from his/her knowledge about the business, and use this information in an "approximate Stackelberg game" to produce an offer.

In this study, two benchmarks have been used to evaluate the contract proposed, namely: independent and central planning maximal profits, and the performance measures were defined in their terms. These performance measures have a clear meaning and are easily determined for any instance of the contract. However, the determination of the complete set of viable and optimal contracts, the subset of contracts that lead to full coordination is not trivial. The models developed for the benchmarks and for a given instance of the contract, have allowed to derive sufficient conditions for the optimal capacities of any given contract instance, as well as for central planning. The existence and uniqueness of the companies' optimal capacities, for the contract situation as well as for the benchmarks –independent and central planning– have been proved. It has also been shown that the optimal capacities under the contract are never smaller than without it.

Unfortunately the optimality conditions are not explicit in terms of the contract parameters and environment setting. Thus, a mapping from the optimal capacities to the set of optimal viable parameter triples is hard to obtain. So, in this research, only a limited sample of viable and optimal contracts has been numerically determined for two particular settings. These numerical results, were obtained by means of a pattern search algorithm on a bounded subset of possibly-meaningful contract parameters starting from different points in a regular three-dimensional grid. This procedure has generated many fully coordinating and viable contracts with a quite wide range

of partition of the total gain between the contracting parties. Though very particular, these limited results are encouraging.

There are several aspects of this research that collectively make it an original inquiry on the formal coordinating supply-contracts.

First, in contrast with most of the literature, both companies are manufacturers, implying a finite short-term production capacity in each one. This is quite distinctive since, to date, all the studies of the similar coordinating-contracts consider one manufacturer and one distributor. The inclusion of capacity decision in both parties implies that no one can sell more than the (medium-term) capacity decided under risk. In contrast, if one of the parties is a retailer (usually assumed to have no short-term capacity constraint) then, in case the demand turns out to exceed the committed capacity, it is still possible to sell more by purchasing in the spot market. In addition, since manufacturer-to-distributor relationships occur only at the downstream-end of the supply chain manufacturer-to-manufacturer relations are probably more numerous in most supply chains. Thus, the added complexity of analyzing a two manufacturers situation is well justified.

Second, stochastic market demand is assumed for both companies, giving rise to the possibility of situations where market governance is more attractive than coordination through contract, something not admitted in many similar studies that consider one of the companies isolated from the market.

Third, contrary to many contracts studied in the literature, the proposed contract assumes that costs are private information, and does not require disclosure of this potentially sensitive information. However, it is true that this same feature impedes the development of a realistic game for determining the contract parameters. Though some schemes for inferring costs through iterated negotiation have been devised in the literature surveyed, no scheme was found for determination of “optimal” contract parameters in complete absence of symmetrical cost information (perhaps an impossibility). In some particular cases, another stratagem for obtaining adequate contract parameters is having one party choosing from an offered set of contract instances offered by the other.

Fourth, this study focuses on the dyad coordination for optimizing the companies’ joint expected performance, rather than focusing on the benefit for a single company of the dyad as in some of previous works.

Fifth, in contrast with some contracts whose strength relies heavily on forced compliance in the contract proposed, forced compliance is assumed only in what concerns the supplier actually reserving the capacity stated in the contract. However, in many actual settings, capacity inspections may be

feasible, making this assumption a quite reasonable one.

This dissertation is still far from exploring all the most interesting features of the capacity reservation contract with reward-and-penalty set forth here. So, several aspects can be considered in continuation of this research. A first issue to be explored is the relaxing of the assumption that limits to Buyer for buying additional material requirement from Supplier, which was assumed, basically, for simplifying the calculations to get the expected profits. Among the complementary topics to be considered is conducting more sophisticated numeric experimentation, including with other demand probability distributions more representative of the manufacturing setting under study, in order to obtain results more credible. Too, a more complete determination of the viable and optimal contracts, perhaps using an approach capable of exploring subsets of the continuous parameter space of greater interest, could be explored.

Because in actual planning practice, an approach with few scenarios is often used, equivalent discrete models, accounting for statistical dependencies in the scenarios, can be developed and then tested to find how sensitive the precision of these models are to the number of scenarios considered. Also, devising realistic schemes for negotiating the contract parameters, and assessing how effective they are for approaching an optimal contract, is clearly of utmost practical relevance.

Among the interesting extensions is the possibility of obtaining multi-period planning- horizon models that can be explored by means numerical analyses. Also of interest would be the extension for more than one supplier and/or buyer. Concerning compliance regime it would be interesting to investigate what are the effects of removing the assumption of forced compliance and devising ways to induce the supplier to set her capacity according to the contract in a voluntary way.

In the models explored in this research it is assumed that market prices are deterministically known, and demand is only probabilistically known. This assumption does not represent well the concept of spot market. The spot market is often where companies trade, in arms-length deals, their surplus production, and buy their short-term input requirements that exceed the contracted quantities. Spot markets are characterized by a price that fluctuates with the aggregated short-term supply and demand without significant influence of any typical buyer or supplier. Developing models for the proposed contract assuming that, either both companies, or just one of them, can trade in such a spot market, may produce interesting results.