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COMPARATIVE STUDY OF TWO SUPPLY CONTRACTS' IMPACT ON MANUFACTURER AND SUPPLIER PERFORMANCES

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ABSTRACT: *For a manufacturer, the order fulfilment process is triggered by the final customer demand. The manufacturer plans its productions, procurements and deliveries. The supply process is often constrained by long-term supply arrangements defined in framework agreements, containing terms which can deeply impact the partners' performance. On this evidence, the interest of this paper is to compare two different supply contracts. The first one called (Q/t) consists in committing to a certain quantity of components per time period t , whereas the other consists in committing to quantity per horizon of time, noted (Q/Hc).*

Both contracts are introduced and the issued constraints are formalized to be integrated in production planning model. The study then investigates by simulation the impact of both contracts on both partners: the manufacturer, noted OEM (Original Equipment Manufacturer) and its supplier. Simulations are carried out through telecom study case performed within the developed simulation platform. Computational results finally illustrate how the adoption of each contract can impact manufacturer and supplier's performances.

KEYWORDS: *Manufacturing systems, production planning, supply contract, simulations, performance assessment.*

1 INTRODUCTION

The manufacturers are evolving in an uncertain environment. They are involving in supply chains where collaboration among partners is established through contract-based relationships. Indeed, supply contract becomes a useful solution for partners, since each one tries to prevent itself from high threaten risks by ensuring a stability and safety of their activities through negotiating commitments on the contract.

The supply chain contracts have been identified in literature as a powerful coordination mechanism (Arshinder et al., 2008) that provides benefits to supply chain members so that even decentralised and uncoordinated supply chains may behave nearly or exactly the same performance as an integrated one (Wang, 2002); (Cachon, 2002); (Gerchak & Wang, 2004); (Jammerneegg & Kischka, 2005).

Beyond the specific investigation in one kind of contract, the aim of this paper is to investigate two supply contracts through simulations to find out their influence on manufacturer's and supplier's performance.

The paper is organized as follows. The related literature review is presented in Section 2. In Section 3, detailed description of elaborated production planning model is given. Section 4 introduces the simulation framework including study case and architecture of simulation tool. Section 5 is devoted to investigate the computational

results in terms of generated performances. Section 6 concludes the paper and relates further research.

2 BACKGROUND REVIEW

Different supply contracts have been addressed in the literature: buyback (allowing the retailer to return unsold inventory up to a specified amount at an agreed price) in (Lee et al., 2002), quantity flexibility (the manufacturer modifies the order within limits as demand visibility increases) in (Tsay & Lovejoy, 1999), backup (the company commits purchasing units before the selling season, and the manufacturer holds a fraction of the commitment and delivers the remaining) in (Eppen & Iyer, 1997). Revenue sharing (the buyer pays a minimal amount for each unit purchased from the supplier but shares a fraction of the revenue for each unit sold) in (Cachon & Lariviere, 2005), (Chen et al., 2007), (Gerchak & Wang, 2004). In (Tsai & Wang, 2009), the authors use two quantity discount schemes to compare the influence on buying decisions.

In (Taylor, 2002), two kinds of proposed contracts, a “buyback” and “target rebate” contracts, show interest in coordinating a supplier retailer system. In (Cachon & Lariviere, 2005), the authors analyze the strengths and limitations of revenue-sharing contracts in both single- and multi-retailer settings. They point out that these contracts ensure better coordination when retailers do efforts.

(Bassok & Anupindi, 1997) study the flexibility contract, defined as the amount of increase or decrease in an order to be served during a given period; the variation is limited to a percentage of the supplies ordered at the previous period. According to (Liston et al., 2007), it consists of negotiating upper and lower flexibility bounds of each ordered quantity. This contract can be connected with a contract of capacity reservation which offers high flexibility with an availability for placing orders (Henig et al., 1997) and (Serel et al., 2001).

Previously, in (Amrani et al., 2009), the relationship between risks and commitments was deeply studied. Later in (Amrani et al., 2011) simulations prove an effective quantified sensitivity of manufacturer and supplier to different parameters of quantity contract. In this paper, the proposition is strictly different, the aim is to go beyond one kind of contract. The purpose is to extend the analysis by comparing quantity contract and another kind assimilated to capacity contract. Through simulations, the impact of the length of commitment on buyer's and supplier's performance is highlighted.

The main ideas that arise from this contribution comparing to literature are the following possibilities:

- *Extend the quantity commitment:* the quantity commitment is often expressed through the flexibility rate exclusively; in our contribution, its association with a frozen horizon produces more realistic simulations and forces us to interpret relevant industrial situations.
- *Analyze the benefits of the contract to each stakeholder of the supply chain:* in the majority of studies, the buyer's point of view is adopted to treat the performance, disregarding the supplier's point of view. In our work, the buyer's view, supplier's view and global view are simultaneously analysed to provide a wide overview of the simulation results, which are helpful for managers regardless of their position in the supply chain.

3 SUPPLY CONTRACTS RETAINED FOR THE STUDY

Two types of engagement rise according to whether the quantity commitments is on a simple period (noted: Q/t) or on horizon of commitment (Q/H_c). Two types of supply contracts are hence generated.

When a partner commits to quantity contract, the commitment on procurement, signed by the manufacturer, can be of different kinds. Often, the commitment covers each period with flexibility clause in order to adapt supplied quantity to the demand variation. However, the commitment on horizon rather than on period was not fully addressed in the literature.

The idea of this paper is to compare two length of commitment. The second studied commitment is over a

global period of time called (H_c : Horizon of Commitment).

3.1 Supply contract on quantity per period (Q/t)

In this type of procurement commitment, a manufacturer receives on behalf of his customer *confirmed and estimated* orders. These are likely to be modified with the next update (Figure.1).

The manufacturer is linked to his supplier by engagement on the quantities per period, noted (Q/t). On a certain part of the production horizon, called *Frozen horizon FH*, the quantities defined by the procurement plan have values of engagement and could not be modified with the next occurrence of planning. The FH has an aim to sustain the near planning periods in order to stabilize internal activities and to avoid the nervousness in workshops induced by recurrent modifications.

On the other hand, certain flexibility is negotiated on behalf of manufacturer. The modification of the previous orders is often required in order to adapt the procurement plan to the variations of the customers' demand. This flexibility rate represents a percentage (α %) of allowed variation (with the rise or with the fall) compared to values (ordered quantities) issued from the previous planning occurrence.

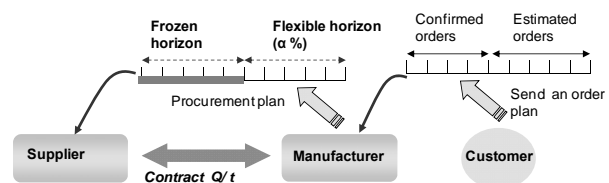


Figure 1: Commitment of quantity/period

3.2 Supply contract on quantity per horizon (Q/H_c)

In this type of supply contract, we propose to observe the effect of a commitment on a given horizon called H_c such as: $H_c \leq H$ (horizon of planning) (Figure.2). H_c is negotiated between the manufacturer and the supplier.

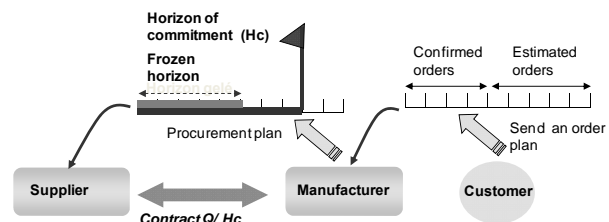


Figure 2: Commitment of quantity/horizon

A manufacturer receives *confirmed and estimated orders*. It is linked to its supplier by a contract, noted (Q/H_c). This type of supply contract constrains the manufacturer to buy an amount of products from the supplier over a negotiated horizon.

4 PRODUCTION PLANNING MODEL FORMALISED WITH TWO SUPPLY CONTRACTS

The developed production planning process is based on linear programming model, with a criterion to maximize under a set of constraints. These constraints come from internal capacities and from the procurement commitments stipulated in the contract. So the planning model, classically found in literature, will be completed with contractual constraints linked to the specific supply contract negotiated between manufacturer and supplier.

The assumptions of the model state that the demand is known along the planning horizon but is able to vary with the market between two occurrences of planning, multi-products (p) and multi periods (t) are considered, finished capacity is assigned and adjustment with additional capacity is ensured by the decision to resort to overtime (additional hours). Each actor carries out the calculation of production, replenishment and delivery plans and the levels of necessary stocks to each period. Planning process is dynamically depicted according to the principle of rolling horizon planning. Any modification that occurs either on the demand or on operational execution can be taken into account at the next planning moment (named incrementing time *inc*).

4.1 Classical production planning model

Before introducing supply contracts commitments formalization along the chain, we summarize hereafter classical production planning model. It includes inventory constraints, capacity constraints and backorders ones.

Decision variables

- $F_{p,t}$ Quantity of product (p) manufactured at period (t)
- $I_{p,t}$ Inventory level of product (p) at the end of period (t)
- $I_{j,t}$ Inventory level of component (j) at the end of (t)
- A_t Additional hours to carry out at period (t)
- $B_{p,t}$ Shortages level of product (p) at the end of (t)
- $R_{j,t}$ Quantity of component (j) waited at period (t)
- $L_{p,t}$ Quantity of delivered product (p) at period (t)
- $C_{j,t}$ Purchasing quantity of component (j) at period (t)
- $D_{p,t}$ Global demand of finished product (p) at period (t)

Costs

- \hat{f}_p Production unit cost of product (p)
- \hat{i}_p Inventory unit cost of product (p)
- \hat{b}_p Shortage unit cost of product (p)
- \hat{l}_p Delivery unit cost of product (p)
- \hat{h} Additional hour unit cost
- \hat{i}_j Inventory unit cost of component (j)
- \hat{a}_j Purchase unit cost of component (j)
- $\gamma_{p,j}$ Bill of materials coefficients, linking product (p) to component (j) consumption
- α_p Processing unit time of product (p)

PV_p Selling price of product (p)

Parameters of rolling horizon planning

- H Planning horizon length (number of periods)
- PP Planning Periodicity
- inc Step of planning (increment)
- φ Index of first period of next planning $\varphi = inc \cdot PP$
- FH Frozen horizon
- $\alpha\%$ Flexibility rate
- t Planning period index ($t = \varphi, \dots, \varphi + H - 1$)

Other parameters

- p Index for product, $p = 1, \dots, n$
- j Index for component, $j = 1, \dots, m$
- CAPN Nominal capacity limitation
- CAPA Additional capacity limitation
- $\theta\%$ Percentage of authorized capacity extension
- D_{liv} Delivery time from supplier

The objective function (1) tends to maximize the profit resulting from the difference between the sales and the various undergoing costs:

$$\max \sum_{t=\varphi}^{\varphi+H-1} \left(\sum_{p=1}^n PV_p \cdot L_{p,t} - (\hat{f}_p \cdot F_{p,t} + \hat{i}_p \cdot I_{p,t} + \hat{b}_p \cdot B_{p,t} + \hat{l}_p \cdot L_{p,t} - \hat{h} \cdot A_t) - \sum_{j=1}^m \hat{i}_j \cdot I_{j,t} + \hat{a}_j \cdot R_{j,t} \right)$$

Under constraints

$$I_{p,t} = I_{p,t-1} + F_{p,t} - L_{p,t} \quad \forall p = 1, \dots, n \quad (2)$$

$$B_{p,t} = B_{p,t-1} + D_{p,t} - L_{p,t} \quad \forall p = 1, \dots, n \quad (3)$$

$$I_{j,t} = I_{j,t-1} + R_{j,t} - \sum_{p=1}^n \gamma_{p,j} \cdot F_{p,t} \quad \forall p = 1, \dots, n, \forall j = 1, \dots, m \quad (4)$$

$$\sum_{p=1}^n \alpha_p \cdot F_{p,t} \leq CAPN + A_t \quad \forall p = 1, \dots, n \quad (5)$$

$$A_t \leq CAPA \mid CAPA = \theta\% \cdot CAPN \quad \forall p = 1, \dots, n \quad (6)$$

The constraints are valid $\forall t = \varphi, \dots, \varphi + H - 1$.

The equation (2) is a quantity conservation equation; it links the level of stocks and the produced quantity. The equation (3) links the level of shortages to the demand and deliveries. The equation (4) calculates the level of stocks of components according to the receptions, the production and bill of materials coefficients.

The equation (5) gives the limits of production quantities according to the normal capacity and additional capacity. The equation (6) guarantees limitation of overtime in such way that additional capacity is equal to a certain percentage ($\theta\%$) of the normal capacity.

4.2 Contractual constraints in two supply contracts

At this step, we will model the conditions of supply in mathematical form in order to include them as additional constraints in the generic production planning model previously proposed.

4.2.1 Formalization of (Q/t)

This type of contract induces a commitment on quantities per elementary period (t). As the demand is not stable, it is implausible for the manufacturer to commit to all orders $C_{j,t}$ on horizon of planning.

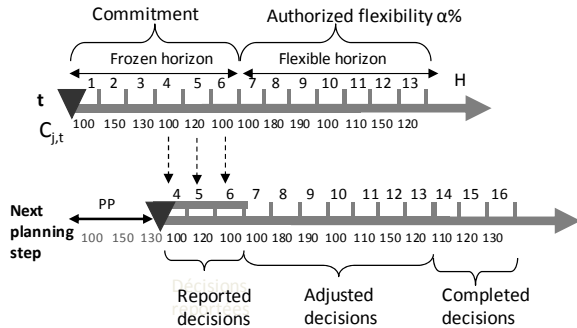


Figure 3: Commitments on Q/t

During the periods of the frozen horizon FH, the manufacturer launches quantities in production; the corresponding supplied components are then transmitted to the supplier and have a commitment value. After the frozen horizon, appears the flexible horizon which, by definition exists to assess global activity volume, and allows the resources estimation necessary to the realization. On this horizon, each industrial actor in the supply chain negotiates the possibility to modify orders with condition to respect a lower and higher bound obtained with flexibility rate.

To ensure receptions of the required components arrivals, noted $(R_{j,t})$, it is necessary to transmit orders $(C_{j,t})$ to the supplier anticipated by the delivery time (equation 7).

The values transmitted as orders have to belong to the interval authorized by engagement ($\alpha\%$).

The constraints of the contract (Q/t) can then be written as follows:

$$R_{j,t} = C_{j,t-d_{div}} \quad \forall t \in \{\varphi, \dots, \varphi + (FH - PP - 1)\} \quad (7)$$

$$F_{p,t}(inc) = F_{p,t}(inc-1) \quad \forall t \in \{\varphi, \dots, \varphi + (FH - PP - 1)\} \quad (8)$$

$$A_t(inc) = A_t(inc-1) \quad \forall t \in \{\varphi, \dots, \varphi + (FH - PP - 1)\} \quad (9)$$

$$C_{j,t}(inc) = C_{j,t}(inc-1) \quad \forall t \in \{\varphi, \dots, \varphi + (FH - PP - 1)\} \quad (10)$$

$$C_{j,t}(inc) \geq C_{j,t}(inc-1) * (1 - \alpha\%) \quad \forall t \in \{\varphi + (HFL - 1), \dots, \varphi + (HFL - 1)\} \quad (11)$$

$$C_{j,t}(inc) \leq C_{j,t}(inc-1) * (1 + \alpha\%) \quad \forall t \in \{\varphi + (HFL - 1), \dots, \varphi + (HFL - 1)\} \quad (12)$$

The equations (8), (9), (10) express the reports of the decisions for each period $t \in FH$ to the next planning step. *Example of equation (8)*: The quantity produced at the planning step (inc) will be deduced from the values of previous step of planning (inc-1).

The equations (11), (12) express the flexibility rate for each period $t \in FLH$. For $C_{j,t}(inc)$, the order may vary between more or less $\alpha\%$ of $C_{j,t}(inc-1)$.

4.2.2 Supply contract (Q/Hc)

This type of supply contract can be perceived as an alternative of the commitment per period except that in this case the engagement relates to an horizon split into number of periods. It induces a commitment on quantities on horizon of commitment (Q/Hc). The quantities delivered from one period to another are variable.

This type of supply commitment provides to the manufacturer some flexibility as he is not constrained any more to buy a fixed quantity per period. Supplied quantities may be distributed on a whole periods of Hc.

Considering this contract, it is assumed that the length of interval Hc can be lower or equal to the horizon of planning H. Moreover, the frozen horizon FH is included in the horizon of commitment (FH < Hc)

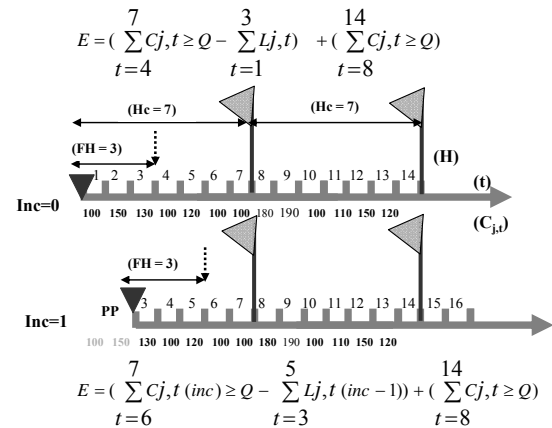


Figure 4: Commitments on Q/Hc

This type of supply commitment requires a detailed attention, because the planning is established with rolling horizon to update the values of the orders, but the engagement is given for a fixed date on the axis of real-time. Therefore, a dynamic constraint of commitment has to be formulated mathematically according to the planning step (inc) and the number of intervals ($i=H/Hc$) of commitments that results from this dynamic phenomenon.

Example for the formulation: in Figure.4, the constraint of engagement (E) is written like this:

$$E = \left(\sum_{t=4}^7 C_{j,t} \geq Q - \sum_{t=1}^3 L_{j,t} \right) + \left(\sum_{t=8}^{14} C_{j,t} \geq Q \right)$$

$$E = \left(\sum_{t=6}^7 C_{j,t}(inc) \geq Q - \sum_{t=3}^5 L_{j,t}(inc-1) \right) + \left(\sum_{t=8}^{14} C_{j,t} \geq Q \right)$$

The deadline of engagement is represented on the axis of real-time. At each new planning inc, the quantities to be delivered have to respect the engagement Q on Hc reduced by effective deliveries on FH (resulting from the previous planning, at step (inc-1).

Important comments:

The two parameters Q and Hc characterizing the contract studied here cannot be dissociated one of the other. None attributed value of engagement Q can be done without referring to the forecast of the demand on a given horizon Hc. To bind these two parameters, we consider a quantity of commitment Q equal to the sum of the estimated demands defined per period on the horizon of commitment Hc, raised or decreased by a certain $\rho\%$ of Q. The parameter ρ makes possible to express the policy of procurement of the manufacturer according to his perception of the future variations of the market. The manufacturer can prefer to make safe its activity while engaging on a quantity Q beyond the estimated needs (positive value of ρ). It can also decide to limit its stocks while engaging on a quantity Q lower than its estimated needs (negative value of ρ), even if it means to order the missing quantities sporadically.

The quantity Q of commitment can be expressed by the following equation: $Q = (1 \pm \rho) \cdot \sum_{t=1}^{Hc} Q_t$

Where: Q_t is the estimated demand for period t.

In general, the choice of the value ρ represents a perception of the increase or decrease of the market demand.

Contractual constraints for (Q/Hc)

The additional variables needed to formulate the supply constraints at each step of planning are the following:

Q_j Quantity of engagement on component (j) purchase on the horizon Hc.

$L_{j,t}^{inc-1}$ Delivery of component (j) for period (t) at step of planning (inc-1)

$C_{j,t}^{inc-1}$ Order of component (j) for period (t) at step of planning (inc-1)

In addition, we should consider the following dynamic variables:

r index of horizon of commitment, $r = 1 \dots R$, such as

R Total number of horizons Hc, R is given by: H/Hc.

Fph First period of the horizon Hc currently considered; it is the dynamic index of period from which the calculation of the last deliveries is done.

η_j^{inc} State of engagement on components (j) at the step (inc), it corresponds to the quantities effectively delivered over the PP periods increased by the orders of components (j) on the frozen horizon reported from previous planning.

The state of commitment is obtained like this:

$$\eta_j^{inc} = \underbrace{\sum_{t=Fph}^{(inc-1).PP+FH-1} L_{j,t}^{inc-1}}_{\text{Effective deliveries}} + \underbrace{\sum_{t=inc.PP+1}^{(inc-1).PP+FH} C_{j,t}^{inc-1}}_{\text{Frozen orders reported from previous planning}}$$

Finally, the constraints of the Q/Hc contract perceived by the manufacturer are written at each step of planning (inc):

- On the first horizon of the commitment Hc

$$(r=1) \quad E\left(\frac{(inc-1).PP+FH}{Hc} + 1\right) Hc \sum_{t=1+(inc-1).PP+FH}^{Hc} C_{j,t}^{inc} \geq (Q_j - \eta_j^{inc}) \quad (13)$$

- On the remaining other horizon of commitments

$$(r=2, \dots, R) \quad \sum_{t=(r-1).Hc+1}^{r.Hc} C_{j,t}^{inc} \geq Q_j \quad (14)$$

The inequality (13) aims to check that the commitment on the first horizon of engagement ($r = 1$) is updated and is calculated dynamically according to the effective last deliveries and the orders of FH.

The inequality (14) extends the expression of the constraint on the remaining horizons Hc of commitments ($r = 2, \dots, R$) that are independent of the dynamics of planning.

$$E = E\left(\frac{(inc-1).PP+FH}{Hc} + 1\right) Hc \sum_{t=1+(inc-1).PP+FH}^{Hc} C_{j,t}^{inc} \geq (Q_j - \eta_j^{inc}) + \sum_{t=(r-1).Hc+1}^{r.Hc} C_{j,t}^{inc} \geq Q_j$$

The idea of constraint (13) in the expression of (E) is to determine the first interval of engagement depending on the dynamic aspect of planning and FH, and the second member constraint (14) determines by the sum of all the remaining engagement intervals.

5 SIMULATION FRAMEWORK

To perform experimentations, supply chain study case simulation platform is required. Several scenarios with various commitments could be performed on developed platform in accordance with the study case.

Supply chain study case deals with telecom supply chain.

The supply chain is composed of a manufacturer *OEM* (Original Equipment manufacturer) (example: Nokia, Ericsson, Lucent...) developing trading relations with a *Parts producer* assimilated to Electronics Manufacturing Services Provider (EMS). This supplier is responsible for the assembly of components that are sold to partners who incorporate them in their own production and put them on the market with their own mark (ex: Flextronics...). Another rank of supplier is also added, such as *Material fabricators* or 2nd tier suppliers (example: Freescale, Philips...).

The simulation tool, developed in (Amrani et al., 2011) is articulated around simulation module and exploitation module. The interest from a simulation tool is to ensure a centralized interface to lead the different scenarios. The

tool was developed to measure performance of the three partners composing the studied telecom supply chain. In the case of this paper, the proposed analysis focuses on *two partners* with the willing to check two contracts for both partners and compare the issued results. Each of manufacturer and supplier carries out their production planning process including the constraints of different supply contracts.

In the Figure.5, the procedure of simulation is shown: each partner performs its production planning from the technical and financial database of the company in order to satisfy the demand plan. Xpress-MP Optimizer is used to solve each mathematical model which performs the local decision making, and computes planning results, such as plans of inventory, plan of procurement, backorders, additional hours,

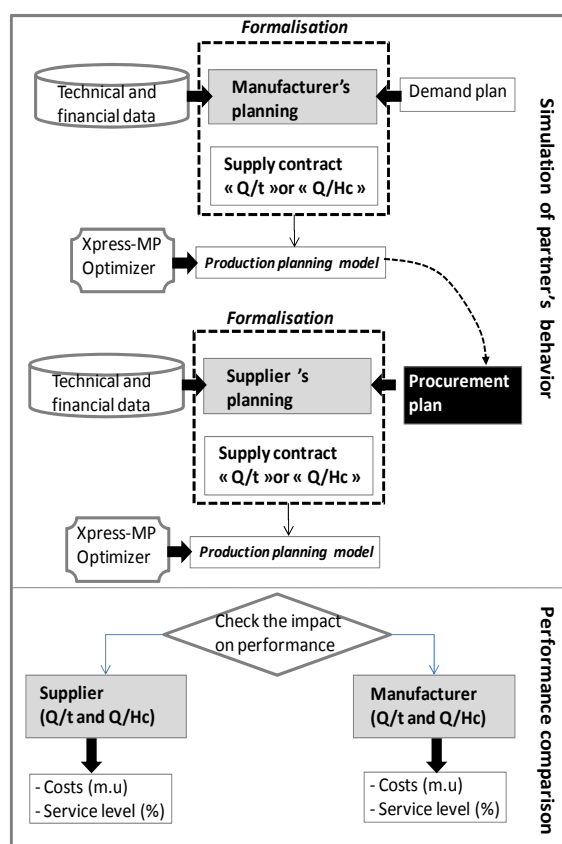


Figure 5: Simulation framework

Procurement plan is then sent to the supplier, after what performance assessment can be led on both partners (manufacturer and supplier) under both supply contracts (Q/t and Q/Hc).

The evaluation will be given in terms of costs measured in *monetary units* (m.u); it represents the aggregation of costs of storage, costs of shortages, and costs of additional hours. Also, we find interesting to perceive the ensured *customer service level*, expressed in (%); it gives an appreciation about the reliability of partner's deliveries. The service level assesses the number of time pe-

riods over the planning horizon where the orders are delivered on time.

6 COMPUTATIONAL RESULTS

At this step, we try a cross analysis of the performances resulting from the application of both contracts to both partners Manufacturer OEM (Original Equipment Manufacturer) and supplier, noted SUPP. Some technical parameters are added hereafter in Table.1.

Production system	CAPA (h)	CAPA (%)	Div	PP	H	OEM	SUPP	$\gamma_{r,i}$ (units)	Raw materials (i)					ζ_p^r (h)	Costs (u.m)																
									MP1	MP2	MP3	MP4	MP5		\hat{f}_p	\hat{i}_p	i_p	b_p	h												
OEM	20	120	3	3	30	3	3	3	2.7	1.35	0.9	1	0.5	5	34	15	14	31.2	17												
																				XPF1	1	2	3	0	0	1	45	17	18.9	42	
																				XPF2	1	0	3	2	0	3	11	18	16.2	36	
FP (p)	110	5000	3	3	30	3	3	3	2	0	0	0	1	7	28	13	8.1	18	17												
																				XPF3	1	2	0	0	3	4	12	19	10.5	24	
																				$\gamma_{r,i}$	2	1	2	0	0	0	5	34	15	14	31.2
SUPP	30	3	3	3	30	3	3	3	1.4	0.86	1.2	0.85	0.87	9	28	13	8.1	18	17												
																				MP1	2	1	2	0	0	0	5	34	15	14	31.2
																				MP2	0	0	0	2	3	0	7	30	14	10.8	24
OEM	30	3	3	3	30	3	3	3	3	1.4	0.86	1.2	0.85	9	28	13	8.1	18	17												
																				MP3	0	0	0	0	1	2	9	28	13	8.1	18
																				$\gamma_{r,i}$	3	1.4	0.86	1.2	0.85	0.87	9	28	13	8.1	18

Table 1: Technical parameters of the simulations

Some couples of parameters particularly characterize the two supply contracts: (FH, α) for the Q/t and (Q, Hc) for the Q/Hc. Their values will be defined when scenarios of simulations will be presented.

We wish here to empirically study the behavior of manufacturer and supplier facing to the same demand variation through the analysis of their performances.

6.1 Initial conditions

In order to carry out a comparison between the two contracts, we must specify comparable initial conditions; with this intention, we look for two initial data sets generating a similar or close performance for the two contracts.

We need to create a situation where the two supply contracts can be applied in comparable situations; thus, we will use, for various simulations, the same *Demand plan*, the same *disturbing demand variation*, the same length of FH.

We decide to put the values of α and ρ equal to zero. Thus, the performances generated by the two contracts are initially similar (without allowing flexibility), in an identical environment with identical disturbances, only the character of flexibility is likely to vary; the initial conditions of comparison appear then favorable to carry out the comparison.

The simulated discrepancy relates to the parameter α of the Q/t contract and ρ of the Q/Hc contract.

6.2 Comparative results

We choose to study the behavior of the partners OEM and Supplier facing a variation of the demand plan over multiple periods. The total demand variation is increased to 16% of initial values. The frozen horizon is fixed at 4 periods.

The adaptation of the partner to the disturbance generates certain costs of adaptation according to the simulated contract and its parameter settings. The results of simulations are presented in the form of overall costs generated by the adaptation, called also adaptation costs.

The Figure.6 shows the evolution of the overall costs when setting contract's parameters. It reveals a downward trend with the increase in the rate of flexibility α (Q/t) contrary to a rise in the costs induced by the increase in the value of ρ (Q/Hc).

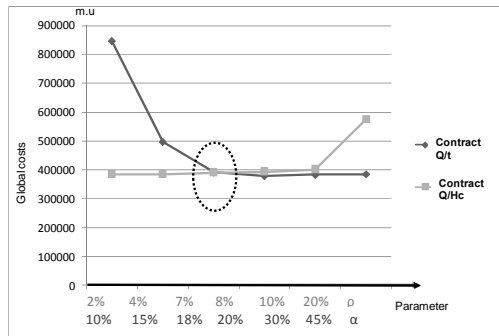


Figure 6: Cost evolution with Q/T and Q/H

For the contract Q/t, we notice that the increase in α proves to be beneficial to the chain (the costs decrease) because essentially the manufacturer records a gain in increasing the flexibility rate during the negotiation and as his part is considerable in the overall costs, it justifies this tendency.

For the contract Q/Hc, the increase in ρ does not help to absorb the variation, and proves thus to be not very useful by bringing additional costs able to penalize the whole costs. The increase in ρ will not bring financial interest but accentuate the storage of final products at last period of commitment horizon Hc.

However, from these results, certainly empirical, emerges an interesting remark. In certain circumstances, the Q/Hc contract proposes solutions being able to be regarded as close to those offered by the Q/t contract from the point of view of the costs of adaptation.

It is the case for $\alpha = 20\%$ and $\rho = 8\%$. However, if performances can be judged like comparable with the financial plan, *the behaviors of partners differ* from one contract to another. We propose to decipher the dissimilarities of these behaviors.

6.3 Study of partner's behaviors

In the case of contract parameterized with $\alpha = 20\%$ and $\rho = 8\%$, the Table. 2 details the specific performances of each actor, as well as the total performance. A first observation makes possible to put forward the differentiation of the local costs regarding similar overall costs.

In table.2, the global costs of adaptation are almost similar using different supply contract Q/t and Q/Hc, How-

ever, we observe different distribution of costs at the partners OEM and SUPP.

Supply contract	Global performance		Local performance	
			OEM	SUPP
Q/t	Costs (m.u)	390440	181212	209228
	Service level (%)	97.89	95.78	100
Q/Hc	Costs (m.u)	389323	113888	275434
	Service level (%)	99.26	98.86	99.66

Table 2: Recorded performances at OEM, SUPP with Q/t and Q/Hc

To deepen the analysis, the following graphs make possible to support the analysis of the results of the Table.2. We choose to examine the adaptation mechanisms that adopt each partner, in terms of level of storage for end products, components, and the recourse to overtime.

6.3.1 Behavior of the manufacturer OEM

The Q/Hc contract allows the manufacturer to have certain flexibility for order's placement (Figure 7), the only constraint being to respect total engagement on the horizon Hc (in general easily honorable when the fluctuation of the demand is high). The storage of components and end products is less used in Q/Hc because of the available flexibility to manufacturer for placing orders.

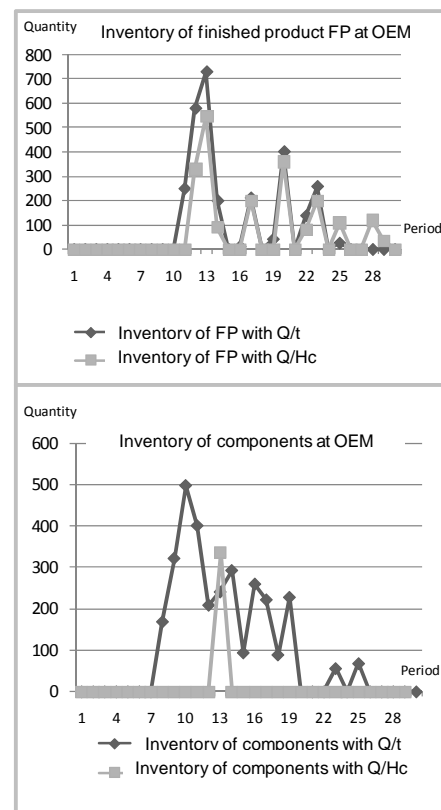


Figure 7: Adjustment of storage at manufacturer with Q/t and Q/Hc

Within the Q/t supply contract, the rate of flexibility α limits possibilities of increased variation acceptance from the supplier, inducing manufacturer to anticipate its requirements in components and consequently to constitute inventory of finished products. (Figure 7).

Let us now depict the Figure.8.

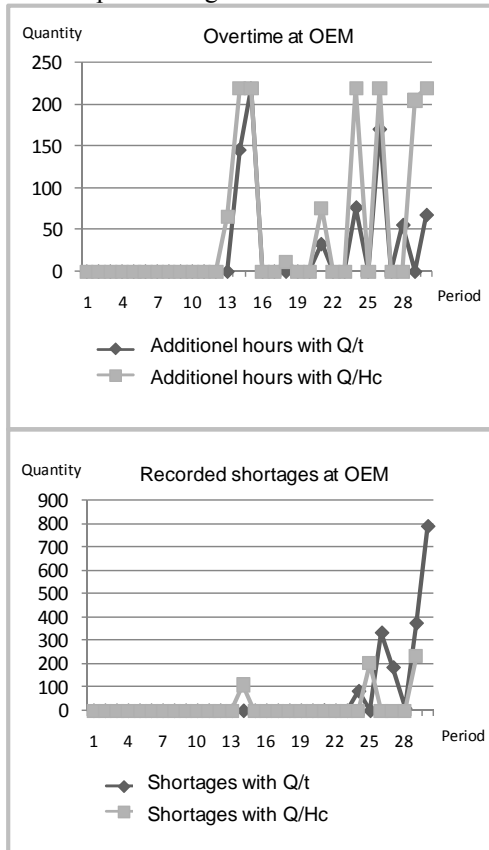


Figure 8: Adjustment of overtime and shortages at manufacturer with Q/t et Q/Hc.

The contract Q/Hc enables the manufacturer to order an amount of components close to its needs, even if it means to resort to overtime; indeed this solution remains economically more profitable than to make a smoothing of upstream production and to endorse its costs.

In Q/t, recourse to overtime is also essential to face the increase in the demand, however shortages appear when the possibilities of upstream smoothing and overtime are exhausted, in Figure.8.

The Q/Hc contract thus proves to be more interesting for the manufacturer OEM. Flexibility offered indeed allows a better adaptation of the manufacturer to the demand variations, because this one enables receptions of components close to the real needs without obligation of storage.

Manufacturer has enough suppleness to satisfy the final demand with less shortages possible.

6.3.2 Behavior of the supplier SUPP

A similar analysis is carried out for the supplier. The demand perceived by the supplier presents low ampli-

tude variations with Q/t contract compared to more pronounced variations observed with the Q/Hc contract. (Figure.9)

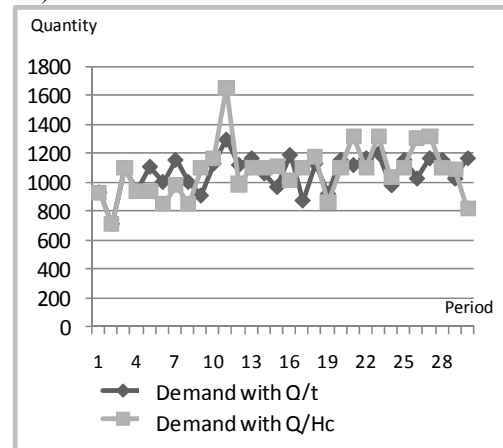


Figure 9: Perceived demand for the supplier

The simulation of Q/Hc proves to be less beneficial for the supplier. The behavior of the manufacturer, sometimes opportunistic, generates a strong variability of the demand sent the supplier who is thus obliged to store by anticipation more finished products and resort to more overtime for facing the undergone variations (Figure.10).

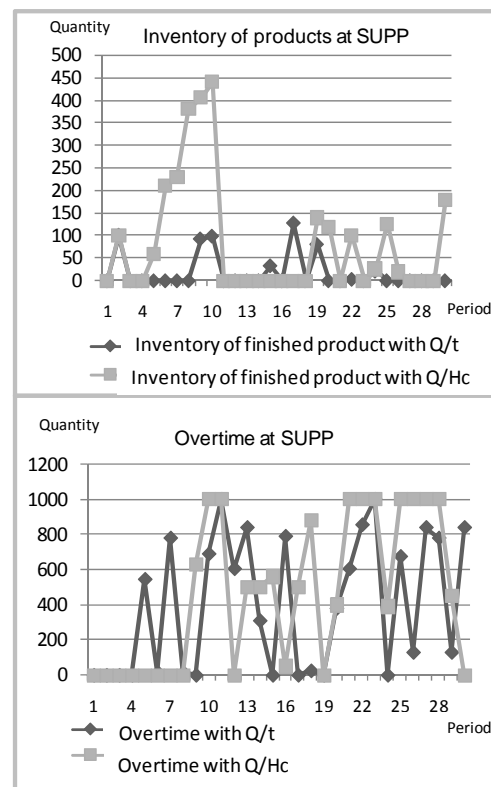


Figure 10: Adjustment of inventory and overtime at supplier

The recorded level of products inventory at the supplier is more pronounced with Q/Hc comparing to Q/t.

It is due the surprising orders of the manufacturer and the flexibility that he gets for placing orders up to his choice.

When analyzing the overtime (in Figure.10), this adjustment, in general costly for the supplier, is outlined when working under Q/Hc.

The choice of the Q/t is then more advantageous to the supplier. The stability gotten on the orders at the supplier is dependant of the manufacturer demand which is spread out period per period. For the supplier, it allows a better use of the production means .

In conclusion, the Q/Hc generates nervousness for the supplier on the finished products quantities to produce per period; it represents a real brake for the achievement of good performance level for this partner.

7 CONCLUSION

This paper leads a comparative study and shows how the choice of contract (Q/t or Q/Hc) may influence the behavior of partners involved in telecommunications supply chain. In this contribution, the paper tends to assess and compare the impact of the two supply contracts on manufacturer's and supplier's performances. A simulation tool has been developed to implement the different strategies of procurement provided by contracts' commitments.

We can deduce that with comparable total performance, two strategies of procurement are confronted according to the bargaining power of each partner. Thus, a manufacturer having a strong influence on his supplier will be able to direct the supply contract towards Q/Hc, this last being more favorable to him. If the bargaining power is equitably distributed between the two partners, each one will seek to maximize its profit, and the Q/t contract is proved to be more adequate because it makes possible to tend towards a better distribution of costs on the whole partners. However, if the supplier has an important bargaining power comparing to the manufacturer (case of specific know how at the supplier), the supplier can refuse the supply contract of kind Q/Hc and prefer the Q/t contract because it constitutes an interesting way to prevent the company from strong variations from the customers and also the supplier may negotiate to the decrease the flexibility rate.

For further developments, the case of multi-sourcing supply will be studied to bring closer the case study to industrial reality, because till now, the simulations were performed under a mono-sourcing situation.

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