

*Full Length Research Paper*

# **A simulation method for Material requirement planning supply dependent demand and uncertainty lead-time**

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Received 6<sup>th</sup> September 2013; Accepted 6<sup>th</sup> February, 2014; Published 28<sup>th</sup> February 2014.

**Materials requirements planning (MRP)** is a widely used method for production planning and scheduling. Planned lead-time (PLT) and lot size are two of the input parameters for MRP systems, which determine planned order release dates. In this paper deals with material requirement planning for a three levels production and assembly system with several types of components and one type of final product, in multi periods. In this paper, we assume that components lead-times are probabilistic. A MRP approach with periodic order quantity (POQ) policy is used for the planning of components. The objective is minimizing the sum of the all components holding cost, final product backlogging cost, final product holding cost and setup costs. The main policies in this model determine the periodic order quantity, and planned lead-times. Monte-Carlo simulation is used to generate numerous scenarios based on the components lead time, and by using Monte-Carlo simulation we can find the suitable solution for this problem.

**Keywords:** planned lead-time; periodic order quantity; uncertainty, Monte-Carlo simulation; Probabilistic lead-time

## **Introduction**

Material Requirements Planning (MRP) is a commonly accepted approach for replenishment planning in major companies (Axsater, 2006). The MRP-based software tools are accepted readily. Most industrial decision makers are familiar with their use. The practical aspect of MRP lies in the fact that this is based on comprehensible rules, and provides cognitive support, as well as a powerful information system for decision-making. Some instructive presentation approach can be found in Baker (1993); Sipper and Bulfin (1998); Zipkin (2000); Axsater (2006); Tempelmeier (2006); Dolgui and Proth (2010) and Graves (2011). In an industrial context, data are often imprecise or uncertain. In production management, it may

for instance be the case for the demand, the lead-times, the resources required, their capacities, the transportation times, the inventory or production costs, etc. When analyzing the state of the art on this subject, so the uncertainty on the demand is a great focus of the literature, while the uncertainty on costs and capacities is also often considered. The uncertainty on the lead-times, which is often mentioned and may have an important impact on the performance of the Supply Chains, is quite seldom taken into account. Component requirement planning in assembly systems is crucial for the companies. By optimizing component supplies enterprises can generate large gains in efficiencies. For

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different reasons (machine breakdowns, transport delays, or quality problems, etc.), the component lead-times (time of component delivery from an external supplier or processing time for the semi-finished product at the previous assembly level) are often random. To minimize the influence of these random factors, firms implement safety stock, but excess stocks are expensive. So, the problem is to minimize stock while avoiding stock-out at the same time maintaining a high level of service thus minimizing the total cost. In contrast, if the stocks are not enough, we will face stock out and corresponding backlogging cost. Therefore, the problem is to minimize the total cost composed of holding and backlogging costs (Dolgui and Prodhon, 2007).

This paper deals with random lead-times. That means the time needed to receive a component may vary from its forecasted time. Lead-time uncertainty may results either some shortages or surplus in inventories. If actual lead-time is random, the planned lead-time can contain safety lead-time that is, the planned lead-time is calculated as the sum of the forecasted (or contracted) and safety lead-times. The latter should be formulated as a trade-off between over-stocking and stock out while minimizing the total cost. The search for optimal value of safety lead-time, and, consequently, for planned lead-time, is a crucial issue in supply planning with the MRP approach. The problem of planned lead-times optimization, when safety lead-times are used, has been given scant attention in the literature. In practice often, average values or percentiles of probability distributions of actual lead-times are used. Gupta and Brennan (1995) studied MRP systems using simulation; they showed that lead-time uncertainty has a large influence on the cost. The statistics done on simulations by Bragg et al. (1999) show that lead-times substantially influence the inventories. Whybark and Wiliams (1976) found the use of safety lead-time more efficient than safety stock.

Assembly systems with random component lead times and lot-for-lot-sizing policy were considered in some research. Yano (1987) considers a two-level assembly system with only two types of components at level 2 (sub-assembly) and one type of components at level 1 (final product assembly). In Tang and Grubbstrom (2003) a two component assembly system with stochastic lead-times (for components) and fixed finished product demand is considered. Ho and Lau (1994); Molinder (1997); Chaharsooghi and Heydari (2010), represent that lead-time is a principal factor foreseeing production and lead-time randomness affects seriously ordering policies, inventory levels and customer service levels. Louly and Dolgui (2002, 2004) consider the case of the objective function minimizing the sum of average holding and backlogging costs, while Louly et al. (2008) studies the case when backlogging cost is replaced with a service level constraint. Faicel (2009) considers supply planning for two-level assembly systems under lead-time uncertainties. It is assumed also that the lead-time at

each level is a random discrete variable. The expected cost is composed of the tardiness cost for final product and the holding costs of components at levels 1 and 2. The objective is to find the release dates for the components at level 2 in order to minimize the total expected cost. For this new problem, a genetic algorithm is suggested. For the latter case, in Louly and Dolgui (2004), the Periodic Order Quantity (POQ) policy was modeled and some properties of the objective function were proven. These properties were used in Louly and Dolgui (2010) to develop a Branch and Bound algorithm and other research by Louly and Dolgui (2011) proposed a model for minimize the sum of the average item holding, finished product backlogging and setup costs. Their developed method can be used for the optimization of time phasing and periodicity for such a MRP system under lead-time uncertainties.

Mohamed-AlyLoully et al (2012) deals with item supply planning in assembly systems that is, where several types of items are needed to produce one finished product. The actual item lead times have random deviations, so they can be considered as random variables. MRP approach with Periodic Order Quantity policy is considered. The aim is to find the optimal MRP offsetting. The proposed model and algorithms minimize the sum of the setup and average holding costs for the items, while satisfying a desired service level.

Loully and Dolgui (2013) considers multi-period Material Requirement Planning (MRP) under uncertainties lead times with no major restriction on the type of the lead-time distribution. They proposed a model and algorithms, which minimize the sum of the setup and holding costs while satisfying a constraint on the service level and the aim of this model is to find the optimal MRP time phasing corresponding to each periodicity of the POQ policy while Sadeghi et al (2013) considers a multi period serial production system for one product and deals with the problem of planned lead-time calculation in a Material Requirement Planning (MRP) environment under probabilistic lead times. It is assumed that lead times for all stages have the same distribution with different parameters. A MRP approach with periodic order quantity (POQ) policy is used for the supply planning of components. The objective is to minimize the sum of fixed ordering, holding and backlogging costs. A mathematical model suggested and then an optimal planning lead-time, ordering quantity and periodic time are determined. Researches in two cases ordering (lot-for-lot and POQ) summarized in Table 1.

This paper deals with material requirement planning for three levels production/assembly system with several types of components and one type of product, in multi periods. We assume that components lead-times are probabilistic. A MRP approach with periodic order quantity (POQ) policy is used for the planning of components. A simulation algorithm is used to minimize the sum of the all components holding cost, final

**Table 1:** Lead-time uncertainly

Paper	Criteria	Parameters	policy	Type system	of	Comments
Yano (1987)	Sum of holding and tardiness costs.	Safety stocks	lot-for-lot	two-level two-item		optimization algorithm
Chu et al. (1993)	sum of the holding cost for the components and the backlogging cost for the assembled product	Safety lead-time	lot-for-lot	One- level Multi-item		optimal values of the planned times for the single-period problem
OuldLouly and Dolgui (2004)	Holding and backlogging costs	Safety lead-time	Lot for lot	One- level Multi-item multi-period		Markovian model for a dynamical multi-period planning
Tang and Grubbström (2003)	Stock-out and inventory holding costs	Safety stocks	lot-for-lot	two-level two-item		Laplace transform
OuldLouly et al. (2008)	minimize the average holding cost for components while keeping a high customer service level for the finished product	planned lead-times	lot-for-lot	one-level Multi-item		Branch and Bound
Faïcel Hnaien, Xavier Delorme, Alexandre Dolgui (2009)	minimize the sum of the holding costs for the components of two levels and the backlogging cost for the finished product	planned lead-times	lot-for-lot	two-level Multi-item	genetic optimization	algorithm
Mohamed-AlyLoulyAlexandre Dolgui (2011)	Sum of the average item holding, finished product backlogging and setup costs.	order periodicity and planned lead times	POQ	Single level Multi-item		Optimization
Louly, Mohamed-Aly et.al.(2012)	Minimize the sum of the setup and average holding costs for the items, while satisfying a desired service level.	Planned lead times	POQ	one-level Multi-item		Optimization
Louly, Mohamed-Aly et.al.(2013)	minimize the sum of the setup and holding costs while satisfying a constraint on the service level	Planned lead times	POQ	one-level Multi-item		Optimization
Sadeghi, H.et, al (2013)	minimize the sum of fixed ordering, holding and backlogging costs	order periodicity and planned lead times	POQ	multi period serial production system		Optimization

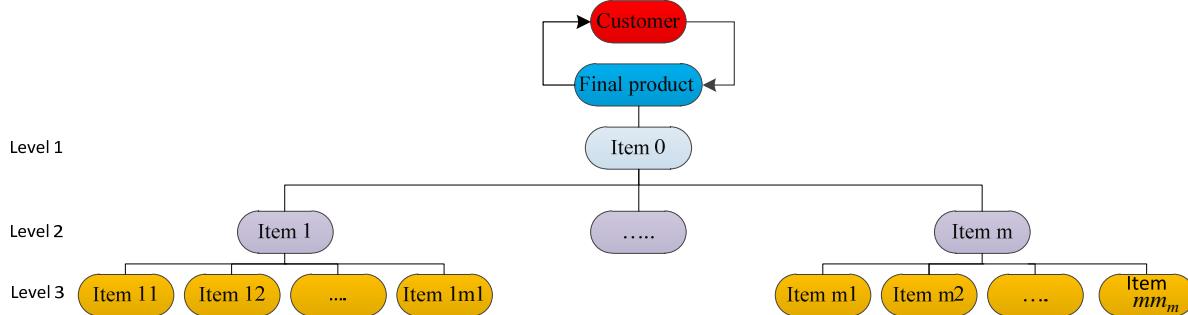
product backlogging and setup costs.

### Problem and model description

A multi period supply planning for three-level assembly systems, with multi components in level 2 and 3 is considered (Figure 1). In this paper, we suppose that, the demand per period is constant. The required quantity of

each component is ordered at the beginning of each period, the demands are satisfied at the end of the period. The unit holding cost for each type of component and the unit backlogging cost for the final product are known. Lead-times for various component orders are independent and actual lead-time is probabilistic for all components. We used POQ policy for ordering.

The components lead times at each level are random discrete variables, and the finished product demand at



**Fig.1:** A tree-level assembly system

each period is fixed. Our endeavor is focused on the following: for each product, to calculate the planned lead times for its components, where the actual item lead times are uncertain. In other hand, production/assembly system is multi-period, in each production orders, we should ordered for needs of  $p$  periods, components are ordered each  $p$  periods, and Products are delivered at the end of each period. MRP approach with Periodic Order Quantity (POQ) policy is considered. The aim is to find the optimal planned lead time corresponding to each periodicity of the POQ policy. The objective is to minimize the sum of total holding cost for all components, final product holding cost, final product backlogging and setup costs. To take into account the particularities of MRP parameterization, the following assumptions will be considered in this paper:

- Components are ordered from external suppliers to satisfy the customer demand.
  - POQ policy is used: components are ordered at every  $p$  periods.
  - The goal of this model is to search for the optimal values of the parameters  $p$  and  $x$ .
  - Probabilistic lead time for all components
- Demand is constant for all period

The following notations are used for proposed model  $t$ :  
Index of period's  $t=1, 2, 3, \dots, m$ :

Total number of component in level 2

$A$ : fixed ordering cost,

$x_0$  : Planned lead-time in level 1,

$x_i$  : Planned lead-time for component  $i$  in level 2.

$x_{ij}$  : Planned lead-time for component  $j$  in level 3 for parent  $i$ .

$a_i$  : Quantity of component  $i$  needed to assemble the finished product

$D$  : Demand for final product in period  $t$

$P$  : components are ordered at every  $P$  period in POQ policy

$h$  : Per unit holding cost per time unit for final product

$h_{ij}$  : unit holding cost for component  $j$  in level 3 for parent  $i$ .

$b$  : Per unit backorder cost per time unit for final product

$l_i$  : Actual lead-time for component in level 2(random variable with known probability distribution)

$l_{ij}$  : Actual lead-time for component  $j$  in level 3 for parent  $i$ . (random variable with known probability distribution)

$f(l_{ij})$  : The probability distribution of lead time for component  $j$  in level 3 for parent  $i$ .

$\hat{C}(x, p)$  : The average of total cost in each period

Variables

$p$ : periodicity

$x$ : planned lead-time for final product  
( $x = (x_0, x_1, x_2, \dots, x_m, x_{21}, \dots, x_{2n})$ ).

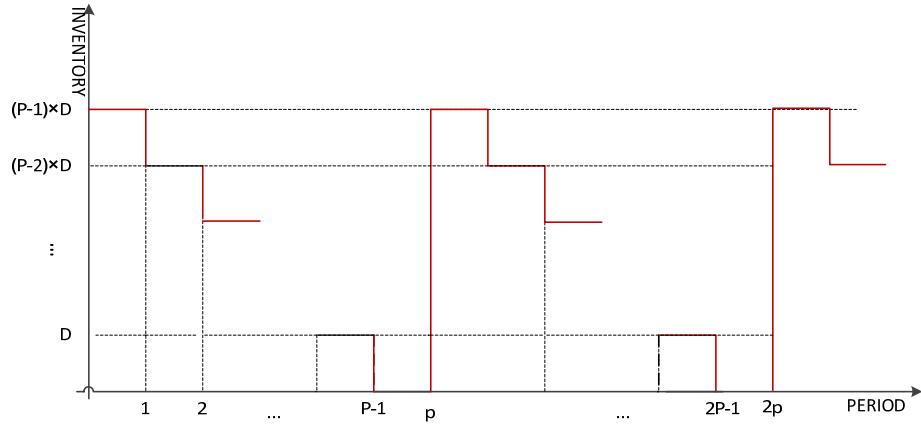
In the model considered, the demand  $D$  of finished products per period is constant and the quantities ordered are the same and equal to  $D_p$ , and  $a_i$  units of component  $i$  is needed to assemble one finished product. The periodic order quantity (POQ) policy issued, with a periodicity of  $p$  periods.

The unit holding cost  $h$  of final period, unit backlogging cost  $b$  of a finished product per period and set up cost  $c$  are known. The distribution of the component lead-time  $l_i$  is also known.

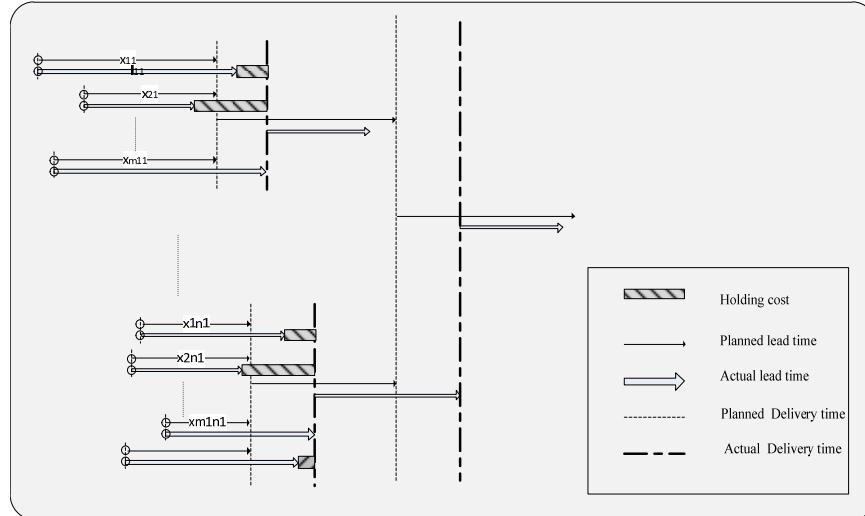
In this paper, an approach is proposed to optimize the planned lead-time  $x$  and the periodicity  $p$  of POQ policy minimizing the sum of setup and holding costs while respecting a service level constraint. The method suggested takes into account the fact that the actual lead times are random.

## MATHEMATICAL MODEL

The lead-time is assumed probabilistic. The planned lead-time for component  $i$  in level 3 is  $x_{ij}$ , planned lead-time for component  $i$  in



**Fig .2:** An illustration of the planning problem for final product



**Fig. 3.** An illustration of the planning problem.

level 2 is  $x_i$ ,  $i = 1, 2, 3, \dots, m$  and planned lead-time for level 1 is  $x_0$ . The order for product is made at the beginning of the periods 1,  $p+1$ ,  $2p+1, \dots$  and there is no order made in other periods. Order quantities are constant and equal to  $PD$  (Figure 2). Taking in to account the fact that the different components on the same level do not arrive at the same time, there are stocks at levels 1 and 2. If the final product is assembled after the due date, there is backlog and therefore we have holding and backordering cost and if product is assembled before the due date, there is stocks and we have holding cost (Figure 3).

The objective is to find planning lead-time for all components and priority order, in order to minimize the total of the holding costs for the components and final product and backlogging cost for the final product.

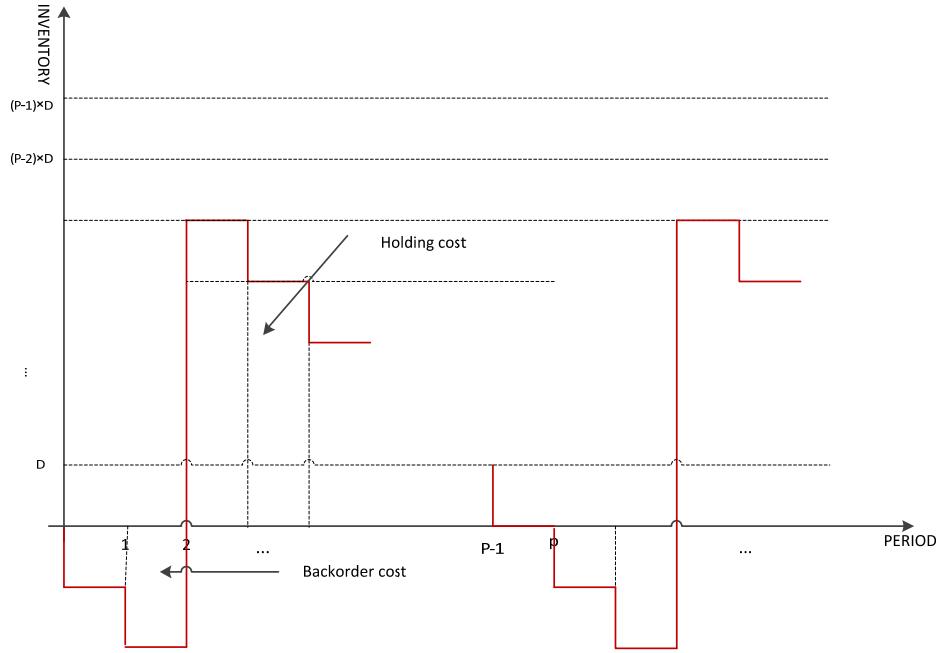
The orders for products are made at the beginning of the periods 1,  $p+1$ ,  $2p+1, \dots$  and ordered for the needs of  $P$  period which is equal to  $PD$  for each ordering. According to Figure 3, we have holding cost for some component in level 2, and for final product have holding, and backordering cost. Therefore, the costs of this model include holding cost for all components and final product, backordering cost for final product and fix order cost for each ordering.

Because of probabilistic lead-time, there are three states in action:

The planned lead-time for first level equal to actual lead-time in this level (see Fig .2)

This state has not backorder and model costs are equal to:

$$C_1(x, p) = \left[ \underbrace{\frac{\text{Setup cost}}{A} + \frac{(p-1)hD}{(p-1)hD + (p-2)hD + \dots + 2hD + hD}}_{\text{Final product Holding cost}} + D \sum_{i=1}^m h_i a_i (x_i + k - k_i - l_i) + D \sum_{i=1}^m \sum_{j=1}^{m_i} h_{ij} a_{ij} (x_{ij} + k_i - l_{ij}) \right] \times p(l_0 = x_0) \quad (1)$$



**Fig. 4.**The planned lead-time is smaller than to actual lead-time for first level

$$\Rightarrow C_1(x, p) = \left[ A + \frac{p(p-1)}{2} hD + D \sum_{i=1}^m h_i a_i (x_i + k - k_i - l_i) + D \sum_{i=1}^m \sum_{j=1}^{m_i} h_{ij} a_{ij} (x_{ij} + k_i - l_{ij}) \right] \times P(l_0 = x_0) \quad (2)$$

Where  $k = \max(l_i - x_i)$ ,  $k_i = \max_j (l_{ij} - x_{ij})$

The planned lead-time for first level is smaller than to actual lead-time for first level. If the final product is assembled after the due date, there exists backlog (Figure 4).

In this state, the cost is equal to:

$$\begin{aligned} C_2(x, p) = & \left[ \underbrace{\text{Setup cost}}_A + \underbrace{\frac{(p-(l_0-x_0+k))(p-1-(l_0-x_0+k))}{2} hD}_{\text{Final product Holding cost}} \right] \times P(l_0 > x_0 - k) \\ & + \left[ bD \frac{(l_0-x_0+k)(l_0-x_0+k+1)}{2} \right] \times P(l_0 > x_0 - k) \\ & + \underbrace{\frac{\text{Items Holding cost in level 2}}{D \sum_{i=1}^m h_i a_i (x_i + k - k_i - l_i)}}_{(3)} + \underbrace{\frac{\text{Items Holding cost in level 3}}{D \sum_{i=1}^m \sum_{j=1}^{m_i} h_{ij} a_{ij} (x_{ij} + k_i - l_{ij})}}_{P(l_0 > x_0 - k)} P(l_0 > x_0 - k) \end{aligned}$$

$$\begin{aligned} C(x, p) = & C_1(x, p) + C_2(x, p) + C_3(x, p) = \\ & A + \left( \frac{p(p-1)}{2} hD + hpD (x_0 - l_0 - k) \right) \times P(l_0 \leq x_0 - k) + \left( bD \frac{(l_0 - x_0 + k)(l_0 - x_0 + k + 1)}{2} \right) \times P(l_0 > x_0 - k) \\ & + \frac{hD (p - l_0 + x_0 - k)(p - l_0 + x_0 - k - 1)}{2} \times P(l_0 > x_0 - k) + p \left[ D \sum_{i=1}^m h_i a_i (x_i + k - k_i - l_i) + D \sum_{i=1}^m \sum_{j=1}^{m_i} h_{ij} a_{ij} (x_{ij} + k_i - l_{ij}) \right] \end{aligned} \quad (5)$$

With simplified cost function, it changes as follows:

Where  $k = \max(l_i - x_i)$ ,  $k_i = \max_j (l_{ij} - x_{ij})$

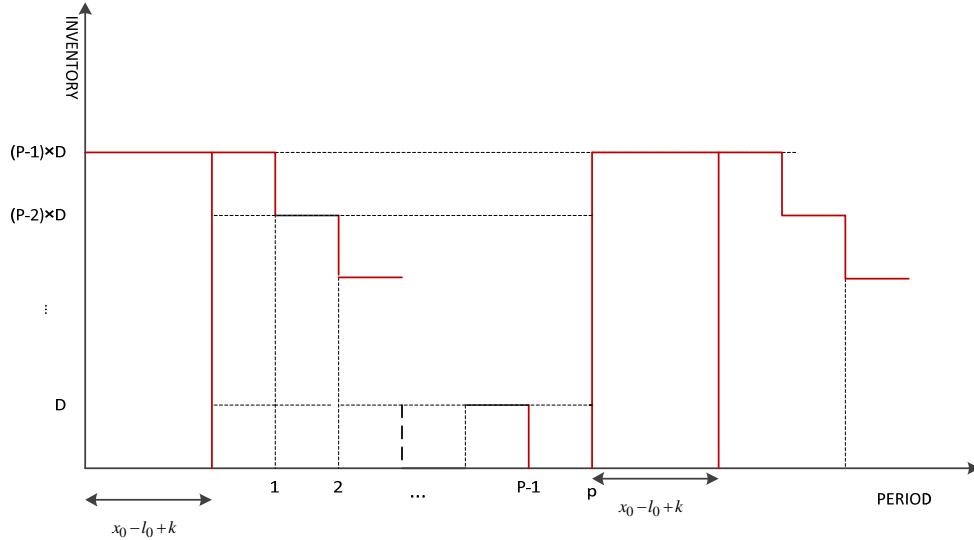
The planned lead-time for first level is bigger than the actual lead-time for first level (Figure .5).

In this state, the cost is equal to:

$$\begin{aligned} C_3(x, p) = & \left[ \underbrace{\text{Setup cost}}_A + \underbrace{\frac{p(p-1)}{2} hD + hpD(l_0 - x_0 + k)}_{\text{Final product Holding cost}} \right] \times P(l_0 < x_0 - k) \quad (4) \\ & + \left[ \underbrace{D \sum_{i=1}^m h_i a_i (x_i + k - k_i - l_i)}_{\text{Items Holding cost in level 2}} + \underbrace{D \sum_{i=1}^m \sum_{j=1}^{m_i} h_{ij} a_{ij} (x_{ij} + k_i - l_{ij})}_{\text{Items Holding cost in level 3}} \right] \times P(l_0 < x_0 - k) \end{aligned}$$

Where  $k = \max(l_i - x_i)$ ,  $k_i = \max_j (l_{ij} - x_{ij})$

Total costs are expressed as follows:



**Fig. 5.**The planned lead-time is bigger than the actual lead-time for first level

$$C(x, p) = A + \left[ \frac{p(p-1)}{2} hD + hpD \times E(x_0 - l_0 - k) + p \left[ D \sum_{i=1}^m h_i a_i (x_i + k - k_i - l_i) + D \sum_{i=1}^m \sum_{j=1}^{m_i} h_{ij} a_{ij} (x_{ij} + k_i - l_{ij}) \right] + \frac{D}{2} (h+b) [(l_0 - x_0 + k)^2 + (l_0 - x_0 + k)] \times P(l_0 \geq x_0 - k) \right] \quad (6)$$

As shown in the previous proposition, the cost of a single period  $k_p + r$  is a random variable. To study the considered multi-period problem, explicit closed forms should be obtained for the average cost and the average number of shortages on the infinite horizon, i.e. for the following expressions:

$$\hat{C}(x, p) = \frac{A}{p} + \left[ \frac{(p-1)}{2} hD + hD \times E[(x_0 - l_0 - k)] p \left[ D \sum_{i=1}^m h_i a_i (x_i + k - k_i - l_i) + D \sum_{i=1}^m \sum_{j=1}^{m_i} h_{ij} a_{ij} (x_{ij} + k_i - l_{ij}) \right] + \frac{D}{2p} (h+b) [(l_0 - x_0 + k)^2 + (l_0 - x_0 + k)] \times P(l_0 \geq x_0 - k) \right] \quad (7)$$

The cost  $\hat{C}(x, p)$  is a random variable (because  $l_0, l_1, \dots, l_m$  and  $k$  are random variables)

Noted that  $x$  is planned lead-time for  $p \times D$  components and  $l$  is actual lead-time for  $D$  components in one period then in the all

equation  $x$  equal to  $\frac{x_p}{p}$  which  $x_p$  is planned lead-time  $p$  periods.

## RESULTS

### Simulation method

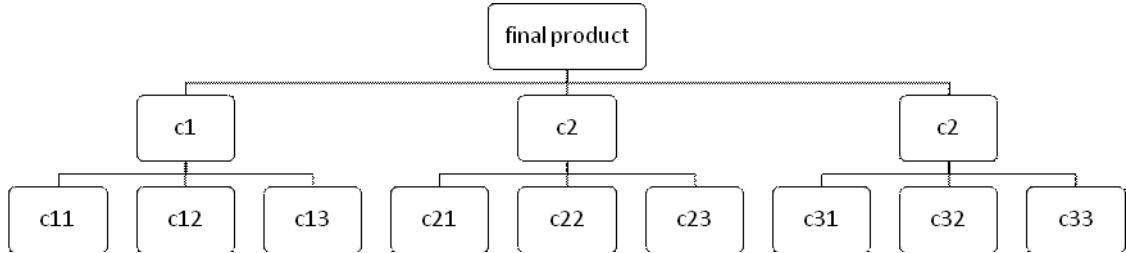
The study objective is to integrate reliability analysis with expansion planning and dispatching decisions. To achieve this objective, we propose a simulation based optimization approach.

$$\hat{C}(x, p) = \lim_{r \rightarrow \infty} \sum_{t=1}^r \frac{C(x, p)}{p \times r} \Rightarrow$$

Then by using Eq. (6), the expressed unit cost will be as follows:

Monte Carlo methods provide a good means for generating starting points for optimization problems that are non-convex. In its simplest form, a Monte Carlo method generates a random sample of points in the domain of the function. We use our favorite minimization algorithm starting from each of these points, and among the minimizers found, we report the best one. By increasing the number of Monte Carlo points, we increase the probability that we will find the global minimizer. Thereby, the Monte Carlo simulation, as a random numerical simulation, becomes a validated method of treating a complex problem, which cannot be solved by general equations, or experimental analysis methods. The principle of the Monte Carlo simulation for statistical tolerance analysis is to use a random generator to simulate the variations of dimension tolerances.

We generate numerous scenarios considering the lead-

**Fig. 6.** The probability distribution and unit holding cost of lead-time for all components**Table 2:** the probability distribution and unit holding cost of lead-time for all components.

level	Components	Lead time distribution	Unit holding cost
1	Final product	$U(5,15)$	20
2	1	$U(1,5)$	10
2	2	$U(2,7)$	12
2	3	$U(3,8)$	15
3	11	$U(5,10)$	4
3	12	$U(4,8)$	10
3	13	$U(5,12)$	1
3	21	$U(3,5)$	2
3	22	$U(3,10)$	12
3	23	$U(2,9)$	15
3	31	$U(9,12)$	9
3	32	$U(7,12)$	2
3	33	$U(5,10)$	5

time of components. Each scenario represents a random answer of components production time. For each scenario, components lead-time is generated randomly by lead-time distributions. The pseudo code of this algorithm is as follows:

Step 1: input all parameters include  $A, h, b, h_{ij}$  and set  $p=1$

Step 2: set  $j=1, c_1 = \infty$

Step 3: generate random data for lead-time

$x_0 \leftarrow$  Random data with  $l_0$  distribution

$x_i \leftarrow$  Random data with  $l_i$  distribution

$x_{ij} \leftarrow$  Random data with  $l_{ij}$  distribution

Step 4: Calculate total cost for this generation

Step 5: If  $C(p, x) < C_p$  then  $C_p \leftarrow C(p, x)$  and  $x_p \leftarrow x$

$j \leftarrow j+1$ , save  $C_p$  and  $x_p$

Step 6: If the stopping criterion for  $j$  is met, stop and return  $C_p$  and  $x_p$

Step 7: If  $C_p < C_{p-1}$  then  $p \leftarrow p + 1$

then go to step 2

Else  
 $C_{p-1}$  is minimum cost and  $x_{p-1}$  is the best answer  
End

#### Example:

Consider the assembly system with two levels which there are 3 components in level 2 and 9 components in level 3. The probability distributions for all components and unit holding cost are shown in Figure 6 and Table 2. And other parameters are:  $A=100, b=5, h=10$ .

#### Solution:

We generate 10,000 scenarios considering the lead-time of components. Each scenario represents a random answer of components production time. For each scenario, components lead-time is generated randomly by lead-time distributions. In each scenario the total cost calculated and in result find minimum cost in 10,000

**Table 3:** Output of simulation

<b>6</b>	<b>5</b>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>P</b>
2631.9	2375.2	2353.6	2539.5	2547.1	2742	Minimum total cost
2601.6	2352.5	2257	2478.9	2456.2	2628.4	Total holding cost
13.6364	2.7273	71.5909	27.2727	40.9091	13.6364	Total backordering cost
78	70	48	39	26	15	$x_0$
12	10	20	6	4	1	$x_1$
42	20	12	21	14	5	$x_2$
24	30	12	12	8	5	$x_3$
54	35	32	27	18	7	$x_{11}$
24	35	28	12	8	7	$x_{12}$
36	25	32	18	12	6	$x_{13}$
18	25	12	9	6	3	$x_{21}$
18	15	20	9	6	6	$x_{22}$
48	10	28	24	16	4	$x_{23}$
66	55	36	33	22	11	$x_{31}$
48	40	36	24	16	11	$x_{32}$
60	40	28	30	20	10	$x_{33}$

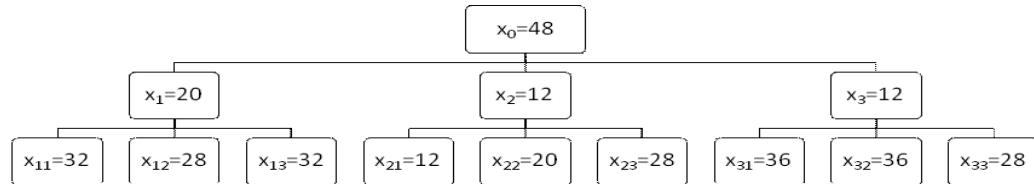
**Fig. 7.** Optimal solution

Table 4: The optimal solution for varies parameter's cost.

$C(x^*, p^*)$	$p^*$	<b>b</b>	<b>H</b>	<b>A</b>	<b>P. No</b>
2353.6	4	4	10	100	1
2453.6	4	4	10	<b>500</b>	2
2359.5	4	4	10	<b>1000</b>	3
3752.2	8	4	10	<b>10000</b>	4
3608.6	3	4	<b>20</b>	100	5
4284.5	3	4	<b>40</b>	100	6
6725.3	1	4	<b>100</b>	100	7
6725.3	1	4	<b>1000</b>	100	8
1569.1	5	<b>10</b>	10	100	9
2175.4	5	<b>50</b>	10	100	10
2594.4	5	<b>100</b>	10	100	11
2918	5	<b>1000</b>	10	100	12

scenarios.

The result of this simulation represent as follows (Table 3): Output of simulation

### Optimal solution

The answer of this system is dependent to the cost

parameters. For example if setup cost was very small rather than holding cost therefore the lot for lot ordering system is better. Figure 7 and Table 4 show the optimal solution for varies parameter's cost. According to the Table 3, with increase in the setup cost, the periodic time is increased. With increase in holding cost, the periodic time is increased and with increase in backorder cost, the periodic time is fixed.

## Conclusion

In this paper considered with a model for optimizing the planned lead-time and order periodicity for production in multi-level production system with random lead-time for all components.

We generate numerous scenarios considering the lead-time of components. Each scenario represents a random answer of components production time. For each scenario, components lead-time is generated randomly by lead-time distributions. For each interaction, the total cost should be calculate and compared with prior total cost, if it is smaller than saved this cost. The proposed a simulation model to minimize the sum of the average holding cost, backlogging product and setup costs. This method, also can calculate the cost of the Lot for Lot policy. The cost of Lot for Lot order policy is when P equal to one. In this paper, a problem is solved to show the efficacy of cost parameter's on optimal planned lead-time and periodicity time. As a future research, one can consider the multi-level uncertainly MRP model, which cannot consider to it at all.

## Conflict of Interests

The author(s) have not declared any conflict of interests.

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