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Simplifying Optimum Lot Sizing Technique Procedures (Wagner – Whitin Technique)

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Abstract

The lot- sizing is the process of determining the quantities of raw materials, parts & sub assemblies, and purchased or produced products at determined periods. So it is a key to determine production records and net requirements. However, when there is a net requirement, it must decide to release an order of purchasing or producing quantities. Lot - sizing technique is one of the key elements of materials requirements planning system (MRP), which responsible for determining an optimal reliable policy by releasing work orders for a planned horizon to ensure the optimal total inventory costs. This study will illustrate an optimal dynamic technique at a single level; the Wagner – Whitin (W-W), aims to simplify the complex computational procedures and design and implement a program based on the computer C^{++} language.

Keywords: Lot sizing, dynamic programming, holding periods.

1- Introduction:

Proceeding from the fact that production planning and control activity is one of the most important activities which given a great attention by the operations managers at the industrial institutions, so a lot of researchers and those who interested in this area found the best methods of production and inventory planning and control through their studies and researches, that led to the emergence of multiple systems had prove their high efficiency for operations management. But the practical problems and gaps between the optimal systems and actual policies of the companies, and the emergence of planning and scheduling difficulties prevented by the application of such systems properly, which provides an opportunity for companies to exploit their available resources optimally. One of these difficulties is make the appropriate decision to determine the optimal method suits the company's requirements of raw materials and subassemblies. So the available options for the companies used of these systems are limited.

The determination of lot sizes in an MRP system is a complicated and difficult problem. Lot sizes are the part quantities issued in the planned order receipt and planned order release sections of an MRP schedule. For parts produced in house, lot sizes are the production quantities or batch sizes. For purchased parts, these are the quantities ordered from the supplier. Lot sizes generally meet part requirements for one or more periods.

The goal of inventory management is to maintain optimal levels of inventory appropriately to the needs of customers and capacity plans, so it always seeks to identify the quantities of materials and parts to be purchased / produced at the appropriate times.

Most lot - sizing techniques deal with how to balance the order / set up costs and holding costs associated with meeting the net requirements generated by the MRP planning process. Many MRP systems have options for computing lot sizes based on some of the more commonly used techniques. It should be obvious, though, that the use of lot - sizing techniques increases the complexity in generating MRP schedules. When fully exploded, the numbers of parts scheduled can be enormous [2].

This is not an easy task, because of proper planning leads to successive successes, and vice versa. Therefore, the operation management trying to make an appropriate decision on the so-called "economic quantities". As is well known, the lot - sizing process is to reduce the total costs of inventory, as well as reducing the number of orders / set up times. Therefore, the algorithm we will discuss in this study guarantees an optimal solution to the dynamic lot – sizing problems at a single level.

2- Scope and purpose:

According to a review of previous studies whether in Iraqi or foreign environments, that studies has focus on classic and dynamic Lot-Sizing Techniques, which showed easy procedures and accounting, as well as the design of computer-based programs for those accounts. It was the share of studies that simplified the procedures and calculations of the economic lot - sizing techniques, especially the dynamic once, from the attention of researchers and specialists in this area a bit, especially in the Iraqi environment. This gap is a subject worthy of study; recently, not any of the Iraqi researchers has design and implement a computer-based program to simplify the procedures for the optimum lot sizing technique; Wagner-Whitin algorithm (W-W). The computational procedures and complex records restricted this approach from being adopted as an optimal technique to make a decision about determination the appropriate size of a production / purchasing amounts for industrial companies and institutions. Computational procedures for this method were conducted by own hand, which does not guarantee the accuracy to give the results, as well as the length of time required to do so.

3- Wagner-Whitin (W-W) Algorithm

It is an optimizing lot – sizing technique emerged in 1958 as one of the applications of dynamic programming[1] techniques [5]. It is dynamic in the sense that it deals with demand that varies over a discrete horizon and generates variable lot sizes economically to satisfy that demand. It tries all possible combinations of orders in a sequential systematic manner, while reducing the size of problem by eliminating

[1] Actually, Wagner – Whitin algorithm is based on a forward dynamic programming formulation. Although the forward formulation has some advantages for planning analysis, some specialists used the backward programming formulation, see (Nahmias, Steven. Production & Operation Analysis, 1989).

alternatives proven to be inferior to others. W-W begins with the first period in the planning horizon and evaluates all possible combinations of orders to meet demand in that period. It then proceeds to period 2 and does the same, and so on until the optimal method for meeting demand in all periods has been determined [1]. It does, however, provide good results. The technique is seldom used in practice, but this may change with increasing understanding and software sophistication [3].

4- Assumptions of the (W-W) Algorithm

Wagner-Whitin Algorithm assumes:

1. The basic assumption of the dynamic lot – sizing models is that the aggregate demand of a given period must be known and satisfied in that period.
2. That there is either fairly constant demand or that safety stock must be kept to accommodate any variability in demand [2].
3. The inventory must replenish at one time, so the orders must delivered at one time. This means no previously determined earliest and latest times.
4. A finite time horizon beyond which there are no additional net requirements during the planning period [3].
5. That the cost per unit not dependent on order quantity during the planned horizon. And other costs (ordering / setup cost) are known and independent [4].
6. That there are no grace periods by customers.

The principle of optimality for this problem results in the following system of equations, if we assume:

OTC: Optimum Total inventory Cost for each alternative.

OC: Ordering / Setup cost.

IHC: Inventory Holding Cost.

NR: Net Requirements.

AIC: Accumulative Inventory Cost.

LS: Lot Size.

1-1 = first period only within the planned horizon.

1-2 = first and second periods within the planned horizon.

2-2 = second time only within the planned horizon.

m: means testing additional periods.

To calculate the total inventory cost for the first period only:

- $OTC_{(1-1)} = OC + [\ 0 * IHC * NR_1\ ] \ = OC$

Where (0) denotes to (no holding periods).

The first alternative: issuance an order to cover the first and second period's requirements together

- $OTC_{(1-2)} = OC + [\ 0 * IHC * NR_1 + 1 * IHC * NR_2\ ]$

Where (1) denotes to (bearing one holding periods) (e.g. one week).

The second alternative: the issuance of two separate orders to cover the first and second period's requirements.

- $OTC_{(1-1)(2-2)} = OTC_{(1-1)} + OTC_{(2-2)}$
- $OTC_{(1-1)(2-2)} = OC + [\ 0 * IHC * NR_1\ ] + OC + [\ 0 * IHC * NR_2\ ]$
- $OTC_{(1-1)(2-2)} = 2\ OC$

It is noted here according to this alternative that the order / setup cost will be doubled. The inventory received in these periods will not bear any holding periods and will thus be assigned to maintain inventory for this alternative zero.

IF $OTC_{(1-2)} < OTC_{(1-1)(2-2)}$

Then $LS_1 = NR_1 + NR_2$

Other wise $LS_1 = NR_1$, $LS_2 = NR_{(2-m)}$

If we choose the first alternative policy to determine the optimal first lot size, then we must examine the possibility of adding the needs of additional future periods within the same batch, or issuing two separate orders as follows:

- $OTC_{(1-3)} = OTC_{(1-2)} + 2 * IHC * NR_3$

Where (2) denotes to (bearing tow holding periods) (e.g. tow weeks).

OR

- $OTC_{(1-2)(3-3)} = OTC_{(1-2)} + OTC_{(3-3)}$
- $OTC_{(1-2)(3-3)} = (OC + 0 * IHC * NR_1 + 1 * IHC * NR_2) + (OC + 0 * IHC * NR_3)$

IF $OTC_{(1-2)(3-3)} < OTC_{(1-3)}$

Then $LS_1 = NR_1 + NR_2$, $LS_2 = NR_{(3-m)}$

Other wise $LS_1 = NR_1 + NR_2 + NR_3$

Thus, we study all possible combinations to determine the optimal lot sizes, and the selection of the best alternative from the alternatives tested, and the eliminating of combinations that are not relevant to cover the entire planned horizon.
To simplify logical measures above, the below algorithm can be translated into orders and directives for designing the program which will calculate all sizes and costs of cumulative payments over any long and extended planning horizon, thereby providing a complete record of the results of (W-W) technique.

1. Input the number of periods (PERIODS)
2. Input the holding cost (hc)
3. Input the ordering cost (OC)
4. Input the unit cost (UC)
5. For i←1 to PERIODS
    a. Input the lot size
6. Initialize period ← 0
7. Calculate accumulated holding cost for the 1st period as: aic[0] ← lot[0]*hc*uc*period
8. Calculate total cost as: tc[0] ← aic[0] + Oc
9. Calculate net requirement as nr←lot[0];
10. For period←1 to PERIODS
    a. Calculate accumulating hold cost for holding and for non holding and total cost
    b. For choice←0 to 1 (0 for holding and 1 for non holding)
        i. Add lot[period-choice]*hc*uc*(period-choice) to aic[choice]
        ii. tc[choice]←aic[choice] + oc*(choice+1)
    c. if tc[1] < tc[0] (non holding is preferred)
        i. aic[0]←aic[1];
        ii. tc[0]←tc[1];
        iii. nr ← lot[period];
    d. else (holding is preferred)
        i. add lot[period] to nr
    e. Print results

The following is the computer programming of W-W lot sizing writing in C^{++} Language with an example of 6 periods.

```
E:\OP\OP.EXE
Optimal Policy for Inventory Management
Number of Periods=6
Holding Cost=.25
Issuance Cost=2500
Unit Cost=50

Lot(1)=1000

Lot(2)=1500

Lot(3)=1400

Lot(4)=2000

Lot(5)=2500

Lot(6)=2500

Results will be stored in a comma seperated value file named: RESULTS.CSV
_
```

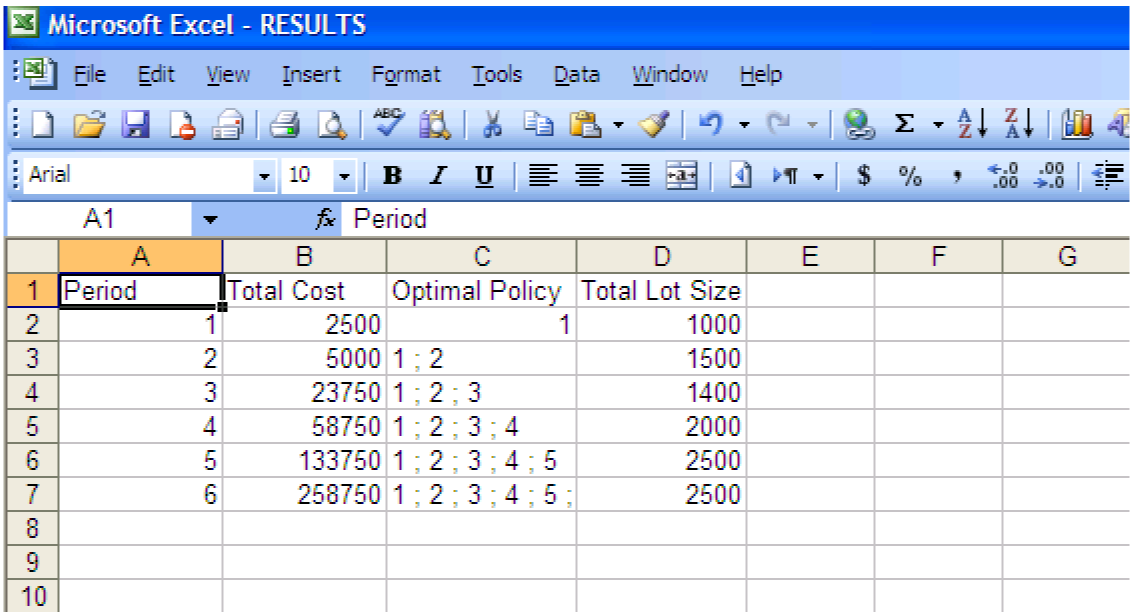
Figure 1: an example of 6 periods planned horizon.

The running of computer programming in C++ to solve the algorithm shown in figure 2:

```
for(period=0 ; period < periods ; period++)
{
  cout << "\nLot(" << period+1 << ")=";
  scanf("%d", &lot[period]);
}

// Print heading for results
fprintf(fp, "Period,Total Cost,Optimal Policy,Total Lot Size\n");

// Clculate the cost for the 1st period only
period=0;
ahc[0]=lot[0]*hc*uc*period;
tc[0]=ahc[0] + ic;
nr=lot[0];
strcat(final_choice,"1");
fprintf(fp, "%d,%.2f,%d,%d\n", period+1, tc[0], period+1, nr);

for(period=1 ; period <periods ; period++)
{
  for(choice=0 ; choice<2 ; choice++)
```

Figure 2: a part of the computer programming.

The results are shown in figure 3. Note here, it tries all possible combinations of orders in a sequential systematic manner, as described in fig. 3, the optimal policy is(1-2-3-4-5-6) which release an order to cover the requirements of 6 periods.



	A	B	C	D	E	F	G
1	Period	Total Cost	Optimal Policy	Total Lot Size			
2	1	2500	1	1000			
3	2	5000	1 ; 2	1500			
4	3	23750	1 ; 2 ; 3	1400			
5	4	58750	1 ; 2 ; 3 ; 4	2000			
6	5	133750	1 ; 2 ; 3 ; 4 ; 5	2500			
7	6	258750	1 ; 2 ; 3 ; 4 ; 5 ;	2500			
8							
9							
10							

5- Conclusion:

This paper studies the optimum lot-sizing problem with one single item. An efficient implementation of forward dynamic programming algorithm was proposed to solve the problem for general multi – stage lot – sizing problems. The algorithm we discussed in this study guarantees an optimal solution to the dynamic lot – sizing problems at a single level. Results have shown that the efficient implementation of the dynamic programming algorithm has reduced computational time by 50%, although it has not reduced its complexity.

This study offers an integrated program to calculate all possible combinations of the (W-W) technique, which allows researchers and specialists and industrial institutions to make the appropriate decision to determine an economical lot size suitable for its policies of reducing total inventory costs, and to avoid the risks of long term storage, especially for products with large, multi- levels product structure file.

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