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Establish Integrated Methodology for Purchasing Department in Supply Chain to Reduce Total Operational Costs

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Abstract—**Manufacturers need a strategy to decrease total costs for items and to increase customer satisfactions. Purchasing department receive the items from suppliers at the same time of the demand is one of the keys of decreasing the risk for the manufacturers.**
Just –In-Time (JIT) model is one of the ways for achieving this goal , but it may not be the optimal solution. The first reason is , in the JIT model the manufacturers order the items whenever they need to meet the demand . The second reason is , by increasing order quantities, the price and shipping cost per item will be decreased , although in a JIT model , the price breaks for purchasing and transportation costs may not happen at all time points.
A new methodology covers pull system , push systems ,short planning horizon , long planning horizon, pull and push systems and applied in Wasit company.In this paper, we used two models to reduce total costs in this proposed methodology, total cost consist from purchasing, holding and transportation costs, it using two models and solving by genetic algorithm (GA) to determine the best order quantity.

Index Terms—**Purchasing department ,Cost , Genetic algorithm, JIT.**

I. INTRODUCTION

In today's competitive operating environment it is impossible to successfully produce low-cost, high-quality products without good suppliers. Thus, one of the most important purchasing decisions is the selection and maintenance of a competent group of suppliers[1].
Sometimes buyers have to choose among a set of suppliers by looking at some predetermined criteria such as, quality, reliability, technical capability, lead-times etc., even before building long-term relationships. To accomplish these goals two basic and interrelated decisions must be made by a firm. The firm must decide which suppliers to do business with and how much to order from each supplier [2].

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Production Planning and Control (PPC) is concerned with satisfying customer demand for products with supply provided by limited manufacturing resources .Decisions made in the framework of PPC are considered in terms of their large economic impact on production systems [3].

Jeunet and Jonard (2000) [4] represent the heuristics method which are extensions of the EOQ method, are to calculate the lot size balancing between inventory costs and start-up costs. There are other more sophisticated techniques such as Minimum Demand Technology methods and Technique for Order Placement and Sizing.

Riddalls and Bennett (2001) [5] study aggregate production-inventory problems and seek out common practical failures to balance setup cost in production with inventory costs of keeping stock. One of the very basic problems seems to be the adequate modeling of batch production costs; it is very hard to determine the true cost of batch sizing decisions.

Park et al.(2006)[6] developed a mathematical model in which the retailer placed orders based on the EOQ policy and allocated them to the multiple manufacturers. In their model, production allocation ratios and the shipment frequencies at the manufacturers as well as the purchasing cycle length at the retailer were formulated to minimize the average total cost at the manufacturers and retailer.

Araújo and Alencar (2015) [7] puts forward a model for selecting suppliers and evaluating the performance of those already working with a company. A simulation was conducted in a food industry. This sector has high significance in the economy of Brazil. The model enables the phases of selecting and evaluating suppliers to be integrated.

II. DETERMINATION OF THE BEST ORDER QUANTITY IN PURCHASING DEPARTMENT

The responsibility of the purchasing department comprises a sort of activities related to the goods and services engage by or utilized within an organization. Based on the organization structure, the purchasing activities might include materials sourcing and availability, determining the right suppliers and vendor certification.
Purchasing can be described as the acquisition of required materials and services for the operation of the business and is one of the key roles in the management of all types of businesses.
The function of purchasing spread across the units of the organization by procurement of the materials required to meet the customer demand and manufacturing schedules.
The objective of decision maker in this department is reduce the total cost for materials required to make demands of

customers, the outline for purchasing department is illustrate in the block diagram in Figure (1),in this paper will focused best order quantity algorithm (BOQA).

Purchasing department determine materials required for accepted demands coordinate with production and inventory departments for each period.

Determine materials required for demands' products depend on bill of materials (BOM) to determine the quantities and timing of materials and components required to ensure the master production schedules (MPS) can be met, and also used material requirement planning (MRP) systems and their latest generations material resources planning (MRPII).

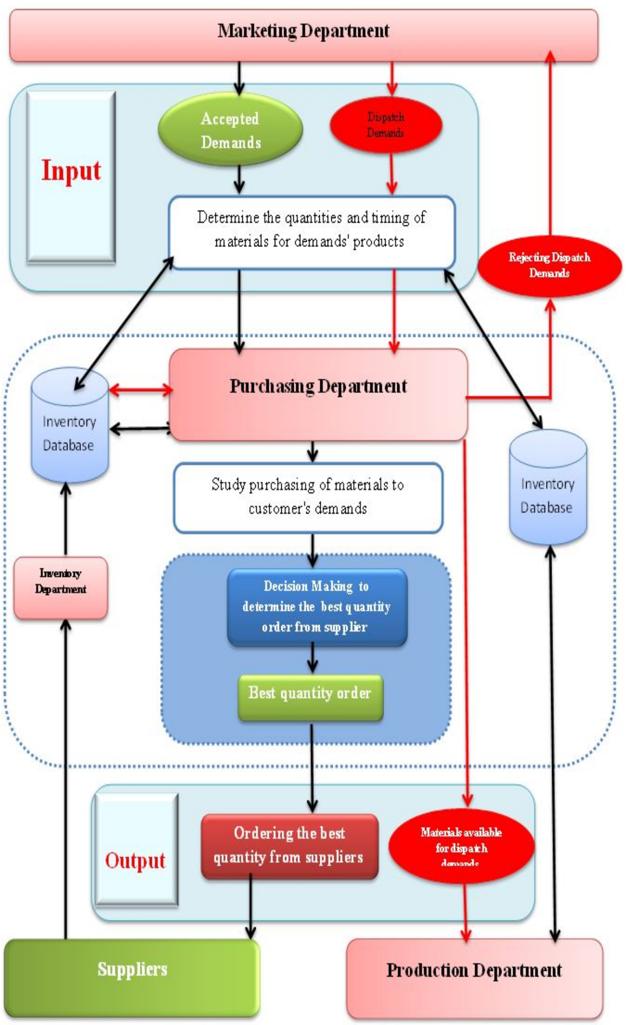

Figure (1) Block diagram for Purchasing Department in Proposed Methodology

III. Algorithm Procedure for Best Quantity Order in Purchasing Department

Purchasing department start to determine the material for demands' products with corporate production and inventory departments for each period.

The steps of these algorithm can be described as following:

Step1. Determine the materials that required to execution accepted demands' products, where the quantities and timing of materials consider as **input** to purchasing department.

Step2. If the materials available enough in inventory to execution accepted demands' products or dispatch demands then update inventory database, and send dispatch demands to production department.

Step3. If the materials available insufficient in inventory to execution accepted demands' products then **step4** , while if the materials available insufficient in inventory to execution to execution dispatch demands then rejecting dispatch demands.

Step4. Study purchasing of materials to customer's demands and determine the best order quantity depend on transportation, purchasing and holding costs that consider as output for BOQ algorithm that focus in this paper.

Step5. Ordering the best quantity from suppliers with minimum total cost.

Step5. Shipment of quantities that requested and update inventory database.

The output of this sub methodology is ordering the quantities from suppliers, materials required for execution the dispatch demands are available in inventory and accepted demand in production department.

Dispatch demands has special treatment because it order with short time and it need to change polices production department and purchasing department, therefore described as red lines in proposed methodology.

The detail of this sub methodology is illustrated in Figure (2).

IV. Best Order Quantity algorithm(BOQ algorithm)[8]:

we used genetic algorithm to reduce all costs together to determine the best order quantity(BOQ).We have a planning horizon with n time points ,where the period between time point could be measured in hours , days , weeks , months or years , depending on the application.

The set of all time points is J={ 0,1,2,3,.., n }. At time point $j \in J$, which is the beginning of time period j , material $i \in I$ has demand D_i^j and inventory level V_i^j where i is the index set of all materials to be delivered by the supplier to the manufacturer and the initial inventory level V_i^1 is known. The plant warehouse has limited stock capacity for each material $i \in I$ depend on lower and upper number of units for all material. The inventory level of material at the beginning of time period $j \in J$ is:

$$V_i^j = V_i^{j-1} + Q_i^j - D_i^{j-1},\ \forall j \in J \setminus \{0\} \quad (1)$$

$$Q_i^j \geq 0 \text{ ,and } Q_i^0 = 0,\ \forall i \in I \quad (2)$$

The inventory level of material i should be greater than or equal to the demand at each time point j when there is no shortage in materials ,thus:

$$V_i^j \geq D_i^j, \forall i \in I, \forall j \in J \quad (3)$$

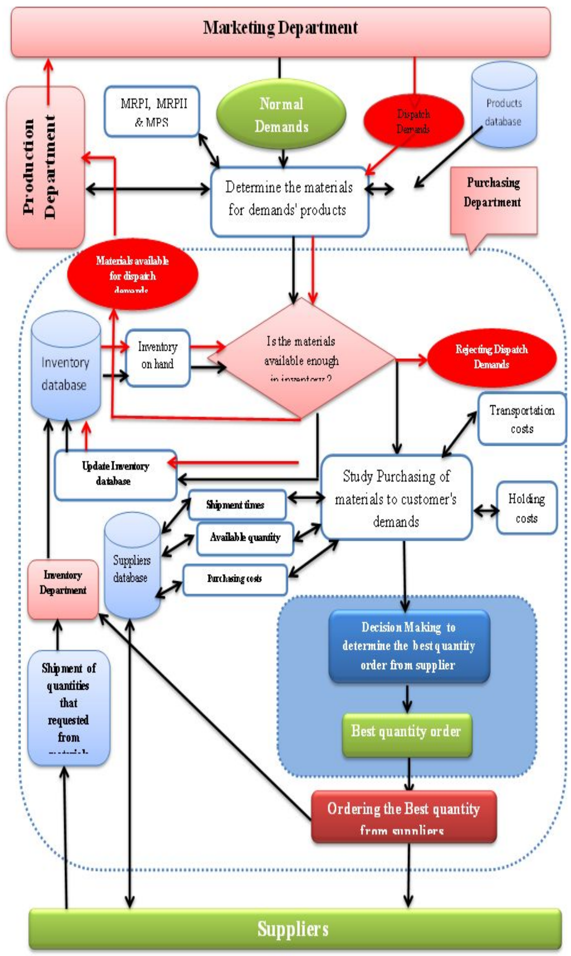

Figure (5) Purchasing Department in Proposed Methodology

The price of each material decrease when the number of material increases. The purchasing cost of order quantity is:

$$f Lower \le D_i^j < Upper\ then\ P_i^j = p_i^k Q_i^j\ ;\ \forall\ i,j \qquad (4)$$

Where:

P_i^j = Purchasing cost for material *i* in time *j*.

p_i^k = The set of price breaks of material *i* , where k={ 1,2,3,….}

The transportation cost for shipping the materials decrease when the number of materials increases, therefore transportation cost of order quantity is:

$$if(Lower \le D_i^j < Upper)then\ R_i^j = r_i^m Q_i^j\ ;\ \forall\ i,j \qquad (5)$$

Where :

R_i^j= Transportation cost for material *i* in time *j*.

r_i^m = The set of price breaks of material *i* ,weher m={ 1,2,3,….}

Material *i* has a unit holding cost h_i per time period . The total holding cost for storing order quantities of material *i* between time points j and j+1 is:

$$H(Q_i^j) = h_i V_i^j\ ;\ \forall\ i,j \qquad (6)$$

The total holding cost for during whole planning horizon is:

$$\sum_{i\in I}\sum_{j\in J} H(Q_i^j) = \sum_{i\in I}(h_i V_i^0 + \sum_{j\in J} h_i V_i^j) \qquad (7)$$

Let $C(Q_i^j)$ be the total cost ,that is the summation of purchasing, holding and transportation costs. Form equations (4) , (5) and (7) we have :

$$(Q_i^j) = \sum_{i\in I}\sum_{j\in J}(P(Q_i^j) + +H(Q_i^j) + R(Q_i^j)) \qquad (8)$$

For finding the optimum Q_i^j , we need to minimize the total cost , $C(q_i^j)$. Thus , the model is to:

Minimize Z= $C(q_i^j)$ (9)

Subject to:

$$\sum_{j=0}^{J} Q_i^j + V_i^0 \ge \sum_{j=0}^{J} D_i^j\ ;\ \forall\ i,j \qquad (10)$$

$Q_i^j >= 0$ *and integer variable*

The genetic algorithm starts with an initial set of solutions which is known as a population. The individuals of the population are called chromosomes which are evaluated according to a predefined fitness function, in our case the total cost .Each chromosome include several genes .The gene represents an order quantity of material *i* at time point j.

V. Application of Proposed Methodology:

This paper applied in Wasit company for textile industries as case study to integrate decision making in purchasing department for textile factory.

The selection of the best order quantity in this factory can be classified to two models depend on inventory amounts.

The first model will attempt reducing the inventory level, therefore will lead to reduce holding cost, that assumed the inventory amounts will equal the demand for next month and will symbol to this model with (BOQ-model 1).

The second model will assumed the inventory amounts will exceed the demand for next month to reduce purchasing and transportation costs and will symbol to this model with (BOQ-model 2).

Purchasing department in this company will determine monthly the materials that required to execution accepted demands' as Table (1). The cotton consider the basic material and bring to this factory from farmers in April, May, June and July months only.

The remain material consider additive materials to manufacturing weave in textile factory. This department study purchasing of materials and determine the best order quantity depend on holding ,purchasing and transportation costs for materials, that can be illustrate in tables (2),(3) and (4) respectively according to plans this company for year 2016.

Table (1) Material Demands for Textile Factory

		Material	V_i^0	D_i^1	D_i^2	D_i^3	D_i^4	D_i^5	D_i^6	D_i^7	D_i^8	D_i^9	D_i^{10}	D_i^{11}	D_i^{12}
$i \in I$	1	Cotton(ton)	100	50	50	300	200	100	0	0	0	0	0	0	0
	2	Starch (ton)	5	2	2	2	2	2	2	2	2	2	2	2	2
	3	Fuel (thousand liter)	200	100	100	100	100	100	100	100	100	100	100	100	100
	4	Color (liter)	50	100	100	100	100	100	100	100	100	100	100	100	100
	5	Hydrogen peroxide(Kg)	600	600	600	600	600	600	600	600	600	600	600	600	600
	6	Caustic Soda (Kg)	1000	750	750	750	750	750	750	750	750	750	750	750	750
	7	Sodium (Kg)	250	150	150	150	150	150	150	150	150	150	150	150	150
	8	Sodium carbonate(Kg)	50	20	20	20	20	20	20	20	20	20	20	20	20
	9	Urea (Kg)	500	500	500	500	500	500	500	500	500	500	500	500	500
	10	Sodium Silicate (Kg)	250	100	100	100	100	100	100	100	100	100	100	100	100

Table (2) Holding Costs Per Unit

i	1	2	3	4	5	6	7	8	9	10
h_i	50000	25000	5000	300	150	100	150	100	150	250

Table (3) The Relation Between Price Costs Per Unit And Material Order Quantity

Material $i \in I$	Price Costs			
	1	2	3	4
1	1-∞			
	2500000			
2	1-10	10-25	25-∞	
	1000000	900000	800000	
3	1-∞			
	150000			
4	1-250	250-500	500-1000	1000-∞
	3500	3250	3000	2750
5	1-1000	1000-5000	5000-∞	
	750	700	650	
6	1-1000	1000-5000	5000-∞	
	800	775	750	
7	1-500	500-1000	1000-∞	
	1500	1250	1000	
8	1-50	50-150	150-∞	
	9000	8500	8000	
9	1-2000	2000-5000	5000-∞	
	1000	900	750	
10	1-250	250-500	500-∞	
	1250	1100	1000	

Table (4) Transportation Costs Per Unit

Material $i \in I$	$\eta_i^m - \eta_i^{m-1}$		
	0-100	100-250	250-5000
1	300000	275000	250000
2	25000	20000	18000
3	25000	20000	15000
4	350	350	300
5	75	75	70
6	80	80	70
7	150	125	125
8	250	100	100
9	100	90	90
10	125	100	100

V1.THE RESULTS TO SELECT THE BEST ORDER QUANTITY IN TEXTILE FACTORY WITHOUT INVENTORY (BOQ-MODEL1):

The best order quantities for this factory can be shown in Table (5).The solutions are given after 300 runs in Matlab program. Each run gives various total cost with a various set of order quantities, then compares them to give best order quantities with minimal total cost, that equal to 1986443850 Daners at run number 255 as shown in Figure (3).

Table (5.) Best Order Quantities for First Model

$i \in I$	$j \in J$											
	Q_i^1	Q_i^2	Q_i^3	Q_i^4	Q_i^5	Q_i^6	Q_i^7	Q_i^8	Q_i^9	Q_i^{10}	Q_i^{11}	Q_i^{12}
1	0	0	0	250	100	50	200	0	0	0	0	0
2	0	1	2	2	2	2	2	2	2	2	2	0
3	0	100	100	100	100	100	100	100	100	100	100	0
4	150	100	100	110	90	100	100	100	100	100	100	0
5	600	600	600	600	600	600	600	600	600	600	600	0
6	500	750	750	750	750	750	750	750	750	750	750	0
7	50	150	150	150	150	150	150	150	150	150	150	0
8	1	9	20	20	20	20	20	20	20	20	20	0
9	500	500	500	500	500	500	500	500	500	500	500	0
10	0	50	100	100	100	100	100	100	100	100	100	0

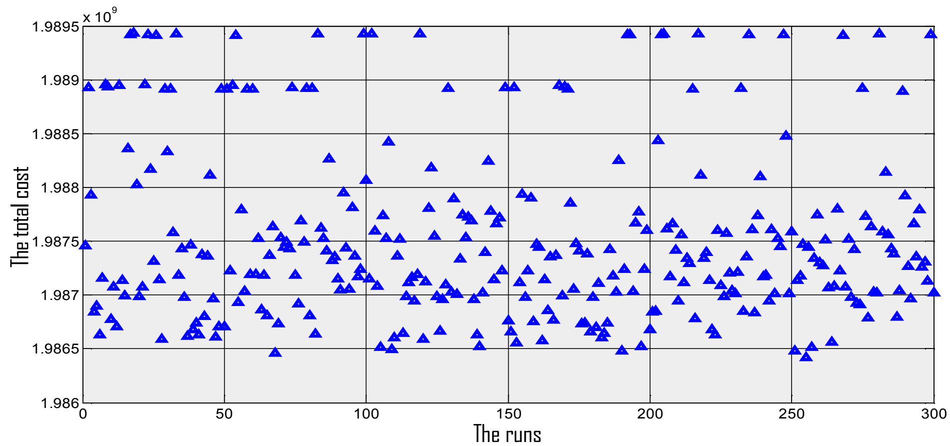

Figure (3) ComparingRuns in the Matlab programming for First Model

Tables (6), (7), (8) and (9) shows inventory levels and holding purchasing costs and transportation costs for all item,respectively.

Table (6) Inventory levels for First Model

$i \in I$	$j \in J$												
	V_i^0	V_i^1	V_i^2	V_i^3	V_i^4	V_i^5	V_i^6	V_i^7	V_i^8	V_i^9	V_i^{10}	V_i^{11}	V_i^{12}
1	200	150	100	50	150	100	0	200	200	200	200	200	200
2	5	3	2	2	2	2	2	2	2	2	2	2	0
3	200	100	100	100	100	100	100	100	100	100	100	100	0
4	50	100	100	100	110	100	100	100	100	100	100	100	0
5	600	600	600	600	600	600	600	600	600	600	600	600	0
6	1000	750	750	750	750	750	750	750	750	750	750	750	0
7	250	150	150	150	150	150	150	150	150	150	150	150	0
8	50	31	20	20	20	20	20	20	20	20	20	20	0
9	500	500	500	500	500	500	546	500	500	500	500	500	2
10	250	150	100	100	100	100	100	100	100	100	100	100	0

Table (7) Holding Costs (Thousand Dinars) for First Model

i ∈ I	j ∈ J 0	1	2	3	4	5	6	7	8	9	10	11	12	Holding Costs
1	10000	7500	5000	2500	7500	5000	0	10000	10000	10000	10000	10000	10000	97 500
2	125	75	50	50	50	50	50	50	50	50	50	50	0	700
3	1000	500	500	500	500	500	500	500	500	500	500	500	0	6 500
4	15	30	30	30	30	30	30	30	30	30	30	30	0	345
5	90	90	90	90	90	90	90	90	90	90	90	90	0	1 080
6	100	75	75	75	75	75	75	75	75	75	75	75	0	925
7	37.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	0	285
8	5	3.1	2	2	2	2	2	2	2	2	2	2	0	28. 1
9	75	75	75	75	75	75	75	75	75	75	75	75	0	900
10	62.5	37.5	25	25	25	25	25	25	25	25	25	25	0	350
Total Holding Costs														108 613.1

Table (8) Purchasing Costs (Thousand Dinars) for First Model

i ∈ I	j ∈ J 1	2	3	4	5	6	7	8	9	10	11	12	Purchasing Costs
1	0	0	0	625000	250000	125000	500000	0	0	0	0	0	1 500 000
2	0	1000	2000	2000	2000	2000	2000	2000	2000	2000	2000	0	19 000
3	0	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000	0	150 000
4	525	350	350	350	350	350	350	350	350	350	350	0	4 025
5	450	450	450	450	450	450	450	450	450	450	450	0	4 950
6	400	600	600	600	600	600	600	600	600	600	600	0	6 400
7	75	225	225	225	225	225	225	225	225	225	225	0	2 325
8	9	81	180	180	180	180	180	180	180	180	180	0	1 710
9	500	500	500	500	500	500	500	500	500	500	500	0	5 500
10	0	62.5	125	125	125	125	125	125	125	125	125	0	1 187.5
Total Purchasing Costs													1 695 097.5

Table (9) Transportation Costs (Thousand Dinars) for First Model

i ∈ I	j ∈ J 1	2	3	4	5	6	7	8	9	10	11	12	Transportation Costs
1	0	0	0	62500	27500	15000	55000	0	0	0	0	0	160 000
2	0	25	50	50	50	50	50	50	50	50	50	0	475
3	0	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	0	20 000
4	52.5	35	35	35	35	35	35	35	35	35	35	0	402.5
5	42	42	42	42	42	42	42	42	42	42	42	0	462
6	35	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5	0	560
7	7.5	18.75	18.75	18.75	18.75	18.75	18.75	18.75	18.75	18.75	18.75	0	195
8	0.25	2.25	5	5	5	5	5	5	5	5	5	0	47. 5
9	45	45	45	45	45	45	45	45	45	45	45	0	495
10	0	6.25	10	10	10	10	10	10	10	10	10	0	96. 25
Total Transportation Costs													182733.25

Figure (4) gives a summarized the percentage of the holding, purchasing and transportation costs.

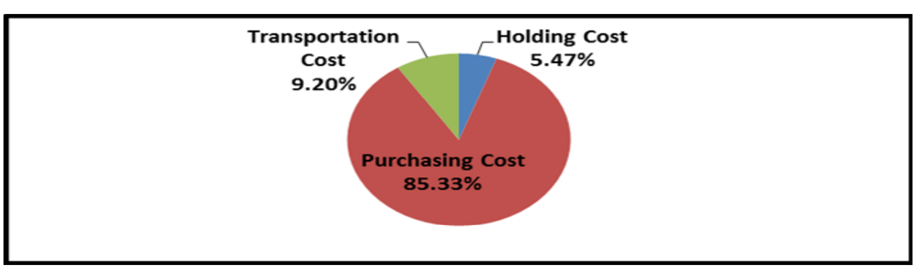

Figure (4) Dividing Total Cost for First Model

The percentage of purchasing cost is biggest value , 85.33% and the percentage of purchasing cost for cotton is biggest value , 88.49% from purchasing cost.

VII.THE RESULTS TO SELECT THE BEST ORDER QUANTITY IN TEXTILE FACTORY WITH INVENTORY(BOQ-MODEL 2):

The best order quantities for this factory can be shown in table (10).The solutions are given after 300 runs in Matlab program . Each run gives various total cost with a various set of order quantities, then compares them to give best order quantities with minimal total cost, that equal to 1995374250 Dinars at run number 34 as shown in Figure (5).

Table (10) Best Order Quantities for Second Model

$i \in$	$j \in J$: Q_i^1	Q_i^2	Q_i^3	Q_i^4	Q_i^5	Q_i^6	Q_i^7	Q_i^8	Q_i^9	Q_i^{10}	Q_i^{11}	Q_i^{12}
1	0	0	0	250	101	49	200	0	0	0	0	0
2	1	2	2	2	2	2	2	2	2	2	0	0
3	100	100	100	100	100	100	100	100	100	100	0	0
4	200	100	100	100	90	100	100	100	100	100	50	0
5	1200	600	600	600	600	600	600	600	600	600	0	0
6	1500	750	750	750	750	750	750	750	750	500	0	0
7	300	150	150	150	150	150	150	150	150	50	0	0
8	20	20	20	20	20	20	20	20	20	10	0	0
9	1000	500	500	500	500	500	500	500	500	500	0	0
10	100	100	100	100	100	100	100	100	100	50	0	0

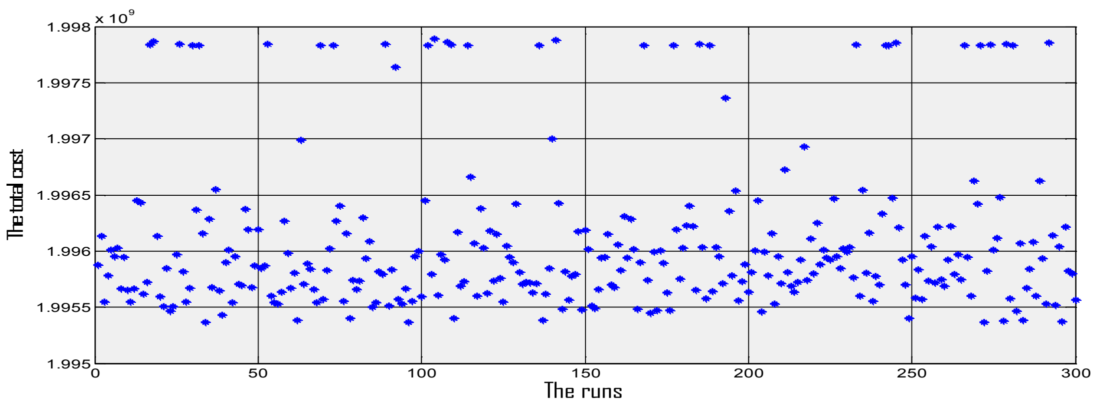

Figure (5) ComparingRuns in the Matlab programming for Second Model

Tables (11), (12), (13) and (14) shows inventory levels , holding costs, purchasing costs and transportation costs for all items in a year, respectively.

Table (11) Inventory levels for Second Model

$i \in$	$j \in J$: V_i^0	V_i^1	V_i^2	V_i^3	V_i^4	V_i^5	V_i^6	V_i^7	V_i^8	V_i^9	V_i^{10}	V_i^{11}	V_i^{12}
1	200	150	100	50	150	101	0	200	200	200	200	200	200
2	5	4	4	4	4	4	4	4	4	4	4	2	0
3	200	200	200	200	200	200	200	200	200	200	200	100	0
4	50	150	150	150	150	150	150	150	150	150	150	100	0
5	600	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	600	0
6	1000	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	750	0
7	250	400	400	400	400	400	400	400	400	400	400	150	0
8	50	50	50	50	50	50	50	50	50	50	40	20	0
9	500	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	500	0
10	250	250	250	250	250	250	250	250	250	250	200	100	0

Table (12) Holding Cost (Thousand Dinars) for Second Model

	$j \in J$													Holding Costs
$i \in I$	**0**	1	2	3	4	5	6	7	8	9	10	11	12	
1	10000	7500	5000	2500	7500	5050	0	10000	10000	10000	10000	10000	10000	97 550
2	125	100	100	100	100	100	100	100	100	100	100	50	0	1175
3	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	500	0	11 500
4	15	45	45	45	45	45	45	45	45	45	45	30	0	495
5	90	180	180	180	180	180	180	180	180	180	180	90	0	1 980
6	100	175	175	175	175	175	175	175	175	175	150	75	0	1 900
7	37.5	60	60	60	60	60	60	60	60	60	60	22.5	0	660
8	5	5	5	5	5	5	5	5	5	5	4	2	0	56
9	75	150	150	150	150	150	150	150	150	150	150	75	0	1 650
10	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	50	25	0	700
Total Holding Costs														117666

Table (13) Purchasing Costs (Thousand Dinars) for Second Model

	$j \subset J$												Purchasing Costs
$i \in I$	1	2	3	4	5	6	7	8	9	10	11	12	
1	0	0	0	625000	252500	122500	500000	0	0	0	0	0	1 500 000
2	1000	2000	2000	2000	2000	2000	2000	2000	2000	2000	0	0	19 000
3	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000	0	0	150 000
4	700	350	350	350	350	350	350	350	350	350	175	0	4 025
5	840	450	450	450	450	450	450	450	450	450	0	0	4 890
6	1162.5	600	600	600	600	600	600	600	600	400	0	0	6 362.5
7	450	225	225	225	225	225	225	225	225	75	0	0	2 325
8	180	180	180	180	180	180	180	180	180	90	0	0	1 710
9	1000	500	500	500	500	500	500	500	500	500	0	0	5 500
10	125	125	125	125	125	125	125	125	125	62.5	0	0	1187.5
Total Purchasing Costs													1 695 000

Table (14) Transportation Costs (Thousand Dinars) for Second Model

	$j \in J$												Transportation Costs
$i \subset I$	1	2	3	4	5	6	7	8	9	10	11	12	
1	0	0	0	62500	27775	14700	55000	0	0	0	0	0	159975
2	25	50	50	50	50	50	50	50	50	50	0	0	475
3	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	0	0	20 000
4	70	35	35	35	35	35	35	35	35	35	17.5	0	402.5
5	84	42	42	42	42	42	42	42	42	42	0	0	462
6	105	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5	35	0	0	560
7	37.5	18.75	18.75	18.75	18.75	18.75	18.75	18.75	18.75	7.5	0	0	195
8	5	5	5	5	5	5	5	5	5	2.5	0	0	47. 5
9	90	45	45	45	45	45	45	45	45	45	0	0	495
10	10	10	10	10	10	10	10	10	10	6.25	0	0	96. 25
Total Transportation Costs													182708.25

Figure (6) gives a summarized the percentage of the holding, purchasing and transportation costs.

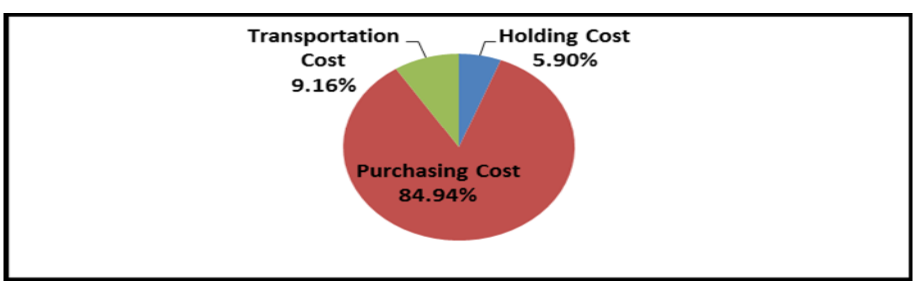

Figure (6) Dividing Total Cost for Second Model

VIII. CONCLUSIONS

The aim of any industrial organization is reduce the costs. This aim is achieved by proposal methodology in this paper to integrate decision making in purchasing department inside internal supply chain.

The main conclusions of this paper are:

1) The implementation this proposed methodology can be used to help decision maker in any industrial organization.

2) Purchasing department is determine monthly the materials that required to execution demands' products from suppliers with minimum total cost and coordinate its decisions with other departments inside company.

3)Determine the best order quantity with minimum total cost in this proposed methodology, total cost consist from purchasing, holding and transportation costs, it using two models and solving by Genetic algorithm(GA).

4)According to the results, first model(BOQ-model 1) is low total cost from second model(BOQ-model 2), but second model is low purchasing and transportation, while holding cost is high from first model.

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