Investigation on bottlenecks to Obtain Optimum Model By minimization of integrated rising Costs in Logistics

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Abstract: In this paper the numerical investigation on bottlenecks of logistic system with the goal of integration and minimization total cost has been conducted. An integrated model has been developed in order to solve the difficulties and turbulent factors that causes the losses in the manufacturing process of supply, production and distribution. In recent researches, we studied the focus on the minimization models of supplement supply chain including of supply, production, distribution and an integrating model of a pair of these functions (supply-production), (production-distribution) and (supply-distribution). But there has been no research work on the relevant elements of the models in function. In general, this paper is consisting the three functions into process of supply chain system in details and existing a new conformed model of integrating three models. To explore the viability of the proposed model, computational experiments are performed on a real-world case. We investigate and study our plan on local sections in AAC(Autoclaved Aerated Concrete light weighted Blocks) plant as a case study while obtained data refers to the expert's reports and experimental data by sales part, inventory and manufacturing managers' reports while assesses to the operations at industrial community of Sharif in Pakdasht, Iran. We will finally give the outcome to decision makers for conservation of the time, costs and energy as they would effect on the production planning, process mapping and control to omit or decrease the bottlenecks that causes the losses. In this paper, in conclusion we point to the significant role of this integrated model through this supply chain system that can be used in any other systems.

[M.H.Tabrizi, Hua-ming Song. **Investigation on bottlenecks to Obtain Optimum Model By minimization of integrated rising Costs in Logistics .** *N Y Sci J* 2017;10(11):70-78]. ISSN 1554-0200 (print); ISSN 2375-723X (online). http://www.sciencepub.net/newyork. 9. doi:10.7537/marsnys101117.09.

Keywords: bottlenecks, Integration, Logistics, Supply chain, total costs.

Introduction

A supply chain is defined as a complex network involved of facilities costs which is designed for procuring, producing and distributing the final products to end users (customers) at requested and right quantities, to the right destinations and the right time. Meanwhile it can be determined for all operational, manufacturing financial systems or expenses for structural varieties associated with internal or external costs by the information and/or material flows by experts and reports through the supply chain that are predicted. In researches, he has modified the supply chain management as a system that included of all activities related to materials recruitment and transforming the stuff from the initial materials (derivation) into the final product (for consumption) and also the relevant informational subjects (Handfild's, 1999). Supply chain management (SCM) is involved in the elements of the information management, inventory management and materials recruitment (logistics) and the relations management among the organs of the supply chain system.

Logistic is determined by Council Logistic Management as the activities of planning, operation, control, warehouse, services and the dependent data to that system from beginning point to the consumption point in achieving the customer's demand. The logistic activities are included of all the orders, purchase, inventory control, planning to the facilities and transportation in supply chain network in three stages of supply, production and distribution.

Suppliers, manufacturers and distributers pay more attention toward logistics systems in order to find a procedure for reducing the costs and customer services (providing the product in customer's favorite time and place), it leads to have an integrating function for the total amount of costs in logistics network as a key parameter for operations of logistics organizing management, the integrated effective logistic management is applied just by organizing the logistics as a system and reducing the total costs in customer services. It is also important to use decision making trials recognizing the linkages between the strategic, tactical and operational decision levels for creating and maintaining competitive advantage.

Despite of it, by considering these facts, this study aims to develop a comprehensive integer linear programming (ILP) for design of integrated model of total logistics cost which would be obtained. The proposed model focuses on supply chain manufacturing, planning and integrates the integrated linear programming (ILP) approaches to include the cost and service level objectives and deal with production processing flow effectively. More specifically, to treat the bottlenecks as surplus costs in levels of supply, production and distribution for the goals and obtain the preferred compromise solution, minimization costs model based on integrated approach is employed. To prove the viability of the proposed approach, computational experiments are performed on a real-world problem.

Literature review

This section is provided to investigate the conveyed researches by an updated overview of the published papers related to integrated models of supply, production and distribution to estimate a perspective on the these topics that leads to reduce the total cost.

In recent researches as studied and found in research that had combined the economic order quantity (E.O.Q) with economic production quantity (E.P.Q), in his research we finally observe a common decision making on (E.O.Q) and (E.P.Q) in different situations that is called as a combined model of Supply- Production (Randolph's 1996).

Govindan integrated the decision-making approach and evaluation laboratory method to handle the important relationships between green supply chain management (GSCM) practices and find the main practices to improve both economic performances and environmental ones (Govindan et al. 2015).

The investigation on the combined model of Production-Distribution is launched from time of studies (Silver, Peterson, 1985) and (Wagner, 1980). Some papers focused on the combination of production and distribution that included of the researches by Bluman feld & burns and Hahm, in their researches we find that the inventory quantity would be conveyed based on E.O.Q and also its combination with the production planning as discrete and indiscrete (Bluman feld & burns, 1985) and Hahm, 1992). Frengs and his cooperators had determined the supply chain network as a strategic decision making problem for Production- Distribution models and in decision making, they assigned the number of locations for initial materials suppliers, productions, inventory between the distribution process and equipment in a limited time (Frengs, 1999). Vidal (1997) and his cooperators have investigated the strategic Production-Distribution models and the base is a mixed integer programming models. Martin (1993) works on the arithmetical model for combined the production and distribution systems consisting four factories, forty inquiry center and two-hundred products. Dasci and Cater (2001) had made a model for supply-distribution system based on indiscrete functions in order to determine the distribution expenses and customer's demands. In research work by Book Binder (1989) and his cooperators, we can observe the combination of the inventory and transportation (production - distribution) that investigated the problems for distributing of the paper with the discrete inventory. In Linda's (2001) research work, it's noted a case study in transferring the local costs and transportation's costs (production-distribution). In the model, the discrete needs of inventory had estimated and based on the past real information investigated, decision making would not be independent of decisions on location-allocations in discrete inventory and the discrete inventory would be obtained as the allocated demands of any single distribution center. In other example, Altay and Green (2006) applied stochastic programming methodology but in different and have a bit more complexity and integrated model of demand and supply that never tried before by any researchers. Most papers try to test the expected criterion in value to find the optimal solution.

In Yang (2002) and his cooperators' research, they made a mixed model by considering to the different layers for production-distribution, they had investigated a series of producers, distributers and customers as a series and with hypothesis of accomplishment of a product in some steps of production in any plant and then the model of their distribution is developed to deliver the customers in a distribution network and also it is reminded that is possible the ability to making an integrated model for supply-production and distribution. Scott (2003) and his cooperators work have developed the mixed functions of transportation and warehousing (production-distribution) in supply chain based on simulation model.

The existed research discoveries in this paper is that, making an integrated model of supply-production and distribution would not be produced and developed as all the steps from beginning of input the row materials (Cement, Lime, Silica, Aluminum powder, Plaster) in supply chain to the step of delivering the product to customer.

In this paper, despite of considering the conditions and initial hypothesizes and their vast will be searching for making an integrated model for logistics. The researches and studies on each one of matters and subjects would assist to solve a limitation or bottlenecks in the determined integrated model.

1. To advance the customers' demands.
2. To consider the producing capacity for each production line or plant.

3. To generate the warehouse based on the warehouse capacity for supply, production and distribution centers.

4. To make balance among inventory, supply, production and distribution.

5. To allocate the transportation path in paths based on costs of each path and to consider the vehicle volume.

6. To consider the products quality, supply, production and distribution.

With the purpose of existing an integrated model for the costs of supply, production and distribution, firstly is necessary to generate the initial model according to the essential hypothesizes for each step of supply, production and distribution and then by considering how much advancement that is possible on the models, there would be made an integrated model of supply-production-distribution based on the initial hypothesizes.

Integrated model for the total cost of logistics with the initial hypothesizes

In the simplest style of plant based on figure 1, consider that it is consisting each parameters as below;

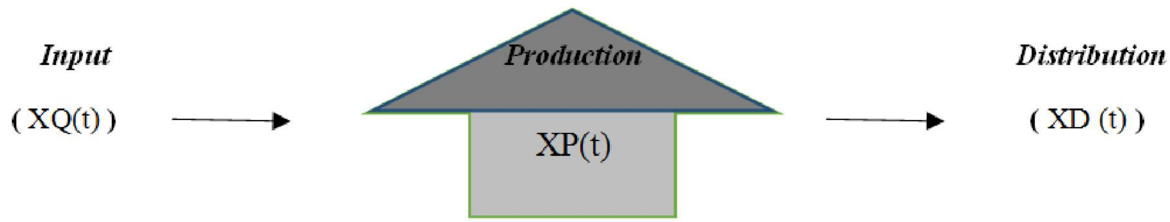

Fig. 1- The plant with the input XQ (t), Production XP (t) and Distribution XD (t)

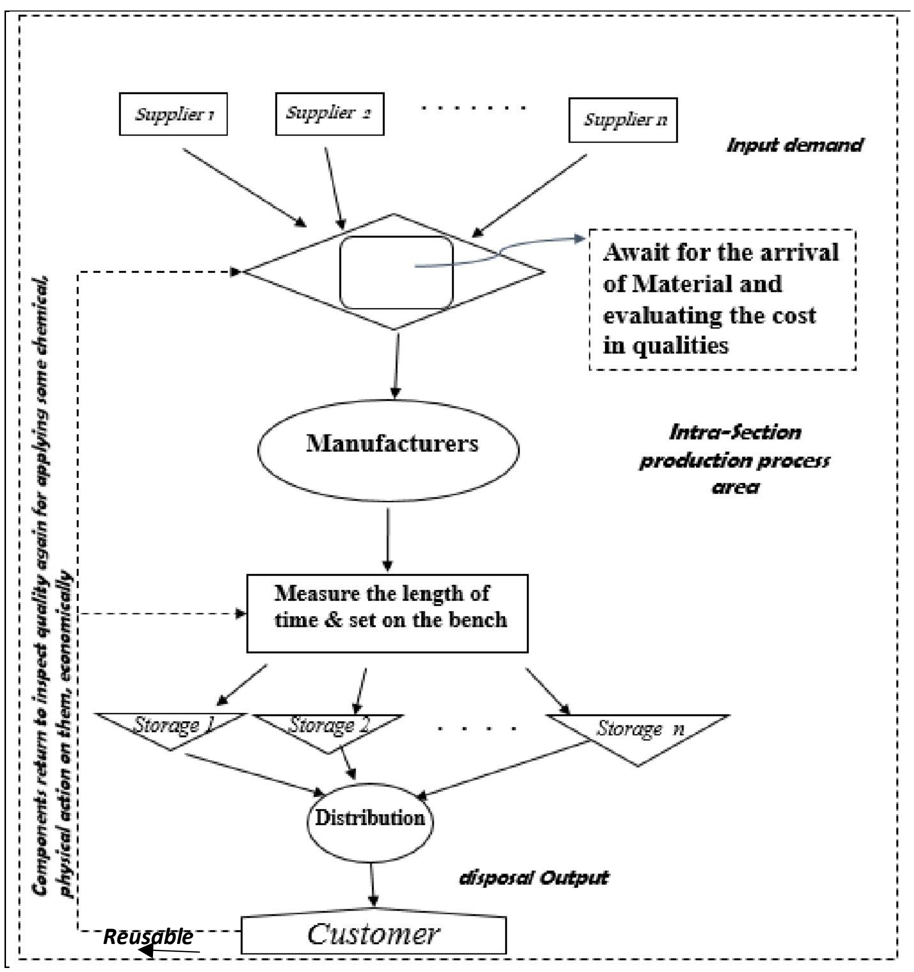

Fig.2 – the conceptual model and Flow process chart of the logistic system

In the Fig.1, *XQ (t)* which is the amount of purchased materials (supply), *XP (t)* is the amount of produced materials and *XD (t)* is the distributed products amount in time (t). At this situation, the questions must be answered such as how much should be bought, how many must be produced and distributed. Meanwhile these solutions should have relation to each other, because of the effect of their costs on each other that is completely observed. Having inventory in each part of these steps leads to be rising the total costs. In this conditions, logistics would be integrated model in three series of supply, production and distribution and for this purpose, all the above series must be indicated based on the hypothesis and the relevant conditions.

Supply, Production and Distribution Models

The purpose of these models are formulating to minimize the total costs and expenses based on the fixed and variable costs in the fields of purchase, maintenance the materials, production and distribution the products. However the following hypotheses would be designed;

1) The demand is fixed and has definite quantity. Obviously, it would be arised with respect to other inventory control policies.

2) The unit cost of supply, production and distribution is consisting of the fixed and variable costs.

3) The suppliers, producers or manufacturers and distributors have the obvious properties and attitudes, quality and strategies.

4) The number of sources, supply, production and distribution is unique and their growing is probable.

The estimated Parameters used in Models

Time periods **t, j ≤ t (t=1,2,3,…, T)**

Q, P, D: Parameters for supply, production and distribution.

ZQ (t), ZP (t), ZD (t): The decision variables in terms of supply, production and distribution at time (**t**).

XQ (t), XP (t), XD (t): The unit cost in terms of supplying materials, production and distribution the product at time.

SQ (t), SP (t), SD (t): The fixed cost in terms of supply, production and distribution at time.

CQ (t), CP (t), CD (t): The variable cost in terms of supply, production and distribution at time.

hQ (t), hP (t), hD (t): The holding cost of materials in terms of supply, production and distribution at time.

IQ (t), IP (t), ID (t): The unit cost of inventory in terms of supply, production and distribution at time.

AQ (t), AP (t), AD (t): The unit cost in terms of supply, production and distribution at time.

M: A large number (Countless).

The optimum model for estimating the total cost of the suppliers is as follow;

TC (Q) *= Fixed cost for purchasing the materials + Variable cost + Holding cost of inventory.*

$$Min = \sum_{t=1}^{T} SQ(t)ZQ(t) + CQ\,(t)XQ(t) + hQ(t)IQ(t)$$

S.t

1) XQ (t) ≤ AQ (t)

$$2)\ \sum_{t=1}^{J} XQ(t) \geq \sum_{t=1}^{J} (t)\, j = 1,2,\ldots,T$$

3) IQ (t) = XQ (t) – dQ (t) + IQ (t - 1)   t= 1,2,..., T

4) XQ (t) ≤ ***M****Z (t)*

5) XQ (t) ≥ 0,   ZQ (t)= 0 or 1

Here is the model of Total Cost for logistic producers as follow;

TC (P) *= Fixed cost of production + Variable cost of production+ Holding cost of inventory*

$$Min = \sum_{t=1}^{T} sp(t)zp(t) + Cp(t)xp(t) + hp(t) \times Ip(t)$$

s.t

1) XP (t) ≤ AP (t)

$$2)\ \sum_{t=1}^{J} XP(t) \geq \sum_{t=1}^{J} d(t)\, J = 1,2,\ldots,T\ ,\ t = 1,2,\ldots,T$$

3) IP (t) = XP (t) – d (t) + IP (t - 1)

4) XP (t) ≤ ***M****ZP (t)*

XP (t) ≥ 0, ZP (t)= 0 or 1

And the model of Total Cost for logistic distributors as follow;

TC (D) = Fixed cost of distributing materials + Variable cost of distribution + Holding cost of inventory.

$$Min = \sum_{t=1}^{T} SD(t)ZD(t) + CD(t) \times D(t) + hD(t)ID(t)$$

s.t

1) XD (t) ≤ AD (t)

2) XD (t) ≥ d (t)

3) ID (t) = XD (t) – d (t) + ID (t - 1)
4) XD (t) ≤ MZD (t)
5) XD (t) ≥ 0, ZD (t)=0 or 1

The objective function of each of three above models in single formulate is minimizing the costs of each operational supply, production and distribution to obtain the optimum result through the constraints, the first constraint from each model is expressed with respect to the quantity in sources of supply, production and distribution. The second constraints are used for responds to demand in all, supply, production and distribution centers in which by considering the needs and required materials per period of time (t). The third constraints indicating the amount of inventory in supply, production and distribution. The fourth constraints are expressed the relations among XQ (t), XP (t) and XD (t) which are the decision making variables of quantitated amount in supply, production and distribution accordingly presented by ZQ (t), ZP (t) and ZP (t) thus are the decision making variables of the quantity zero-one through the time-period, would clear the possibility of supply, production and distribution or might not be done none of the activities as quantitated in their function, shown by a large number of M (e.g. countless in measuring). The fifth constraint is represented by each variables of XQ (t) and XP (t) and XD (t), affirmative and the quantity of variables ZQ (t) and ZP (t) and ZD (t) is counted at least zero and at most one.

The Developed Model as Integrating Total Cost in Logistic

According to the above models in optimization the model of supply, production and distribution which performed in each single model, logistic is influenced by the current materials in supply chain at three areas of supply the materials, production (intra-logistics) and distribution. The relation among the above areas and generating a new model regarding to each one of the conditions that can establish the optimization in supply chain system, would be significant and inevitable to minimize the costs of logistics that leads to improve the system cost processing. Considering the existent variety conflicts of factors for solving problems through the model can lead to increase the complexities and inflexibilities, nevertheless in launching into modeling with the initial conditions, the integrated model will be created and in advance we try to vast and develop the obtained results in models.

Integrating Total Cost in Logistic

According to the researcher's findings that indicated reducing the costs of other parameters in single model would not be influenced on improving the plant operation system, thus the mixture and combined costs of parameters must have been minimized and generalized. However, they discovered that using the optimum procedures in each part of supply, production and distribution the policy to improve the mechanism of supply chain networks, according to researches' findings through the experimental data including Min (1994) and Moore (1973).

Hypothesis of the Integrated Costs Model in Logistic

- There is just one supplier in this model.
- The holding and maintenance cost in all steps of supply, production and distribution are assignable and can suppose it similar.
- The quantity for the suppliers and the plant is assignable.
- The demands for the plant manufacture and production is based on customer's order while numerically is obvious and would be assigned in each period.
- The periods is modified as **t = 1,2,3,..., T**.
- The goods is made of one materials (product).
- One step in production is just considered.
- One center in distribution is just considered.

Each one of above hypotheses would be expandable.

The obtained Model by integrating costs is as follow;

$$Min \quad \sum_{t=1}^{T} SQ(t)ZQ(t) + SP(t)ZP(t) + SP(t)ZD(t) + CQ(t)XQ(t) + CP(t)XP(t) + CD(t)XD(t) + hQ(t)IQ(t) + hP(t)IP(t) + hD(t)ID(t)$$

s.t
1) XQ (t) ≤ AQ (t)
2) XP (t) ≤ AP (t)
3) XD (t) ≤ AD (t)
4) $\sum_{t=1}^{J} XQ(t) + IQ(t-1) \geq \sum_{t=1}^{J} XP(t)\ J = 1,2,\ldots,T, t = 1,2,\ldots,T$
5) $\sum_{t=1}^{J} XP(t) + XP(t-1) \geq \sum_{t=1}^{J} XD(t)$
6) XD (t) + ID (t - 1) ≥ d (t)
7) IQ (t) = XQ (t) – XP (t) + IQ (t -1)

8) IP (t) = XP (t) – XD (t) + IP (t - 1)
9) ID (t)= XP (t) – d (t) + IP (t - 1)
*10) XQ (t) – **M**ZQ (t) < 0*
11) XP (t) – ZP (t) < 0
*12) XD (t) – **M**ZD (t) < 0*
13) XQ (t), XP (t), XD (t) ≥ 0
14) ZQ (t), ZP (t), ZD (t)= 0 or 1

Accordingly, the discrete-time analytical model is formulated to minimize the total operational costs through the whole of supply chain system supply, production and distribution and also the inventory expenses of each one. The first constraint confirms that the purchased amount is lower than the suppliers'. The second constraint assigns the produced amount of products lower or equal to the plant case at that period of time. The third constraint is that the distributed amount of products is lower or equal to store in period of time (t). The fourth to sixth constraints guaranteed that the amount of supply, production is done at the same period or previous periods, meanwhile the distributed amount would respond to the requested amount by people demands in each period of time (t). The seventh, eighth and ninth constraints indicate the amount of inventory, supply, production and distribution, the amount of inventory of each level in the process, would be clear by consuming the aforementioned amount on next step and thus the tenth, eleventh and twelfth constraint which explained before. The application of this proposed model is mostly for place ordering the production (e.g. production of Auto parts) and might be solved this model by advanced software or heuristic methods quickly and easily.

Priority of illustrating Integrated Model On Collecting Three Models

In this model, it should be noted that when a Global model is solved, the obtained solutions would be better in advance than the time that each of supply, production and distribution is solved and minimized in single model. The reason is that, when each model is solved in single model, there would be supply-distribution model, production-distribution model and supply-production. In this case, the inventory of each model would be clear just by considering the next step but in illustrating the integrated model of supply-production-distribution, the total inventory would be considered according to the three steps with each other in the process thus the transformation of the costs will be applied correctly. So the previous costs of one step ago will be lower than minimizing the costs, step by step in single models. Regarding to this transformation in each period, it makes a balance in costs and least of them therefore it would lead to change the decision making in each period.

Numerical Solution Method in AAC[1] Integrated Model

We consider four different time period, it is obvious that in some time periods the supply cost is higher than the other periods. Thus, if we solve the model in single model, the model regarding to the supplier's case, obviously would supply and provide the materials which has the lower cost.

In *table1*, we have the more costs of supply in period 2 and 3, so it's clear the more purchases were in first period and fourth. On the other side, if we consider the production model and if suppose that the variable cost in the first period is higher than the other periods as *table 2* shown that at the first table must have production. Even though because of higher cost in period 3, the production was in period 2 and 4. In distribution model as *table 3* shown, by considering the constraint of responds to demand in each period, it would be necessary to send the products based on the same demanded amount. In *table 4*, explained that the integrated total cost model in supply, production and distribution according to the conditions of supply, production and distribution. Thus based on the purchase prices and inventory costs and production costs, the highest range of purchase happened at the period 1 then period 4, therefore in period 1,2,3,4 the production have done.

Table 1: Supply Model result

Parameter \ Period	1	2	3	4
d (t)	80	80	70	90
AQ (t)	200	200	200	200
CQ (t)	2	4	4	2
hQ (t)	1	1	1	1
ZQ (t)	100	100	100	100
XQ (t)	200	-	30	90
Total cost in Supply	1160			

As shown through *tables 1* to *4*, the total cost for supplying the initial materials of autoclaved aerated concrete blocks is 1160, the production cost is 1870 unit and distribution cost is 2420 unit with the experimental data. In sum, the total costs for supply, production and distribution is 5450 unit but if we solve the model as integrated, as shown in *table 4*, the

[1] Autoclaved Aerated Concrete Plant

total costs is equal to 4110 unit that indicates 1340 unit reduction in costs. This matter is noted that the general sight to the costs of supply, production and distribution cause to the reduction in total costs. This problem will be solved in repeating the numbers and obtain an optimized responds by software Lingo and QM.

Table 2: Production Model result

Parameter \ Period	1	2	3	4
d (t)	80	80	70	90
AP (t)	200	200	200	200
CP (t)	6	3	6	3
hP (t)	1	1	1	1
ZP (t)	200	200	200	200
XP (t)	80	150	-	90
Total cost in Production	1870			

Table 3: Distribution Model result

Parameter \ Period	1	2	3	4
d (t)	80	80	70	90
CD (t)	4	8	3	5
hD (t)	1	1	1	1
ZD (t)	300	300	300	300
XD (t)	80	80	70	90
Total cost in Distribution	2420			

As can be observed the results through the charts as below;

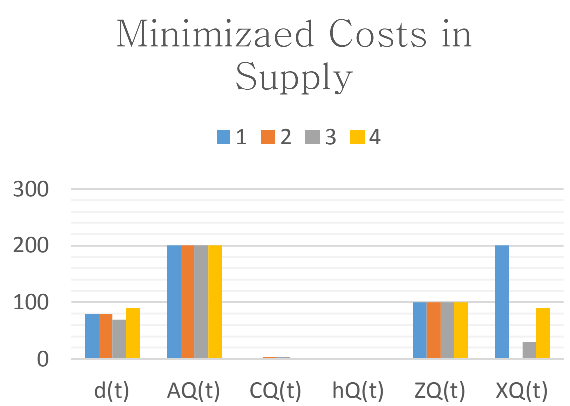

Fig.3- Bar chart for minimized costs in supply

Table 4: The Integrated Model of Total costs as Optimum result

Parameter \ Period	1	2	3	4
XQ (t)	20	30	-	90
XP (t)	80	150	-	90
XD (t)	80	80	70	90
Total cost	4110			

Table 4 confirms that the integrated costs model is the optimum solution in comparison with the total costs of three models supply, production and distribution through the modified periods 1, 2, 3 and 4 as chart 4 is obvious so that there is no cost for the amount of purchased materials in supply and the amount of produced materials.

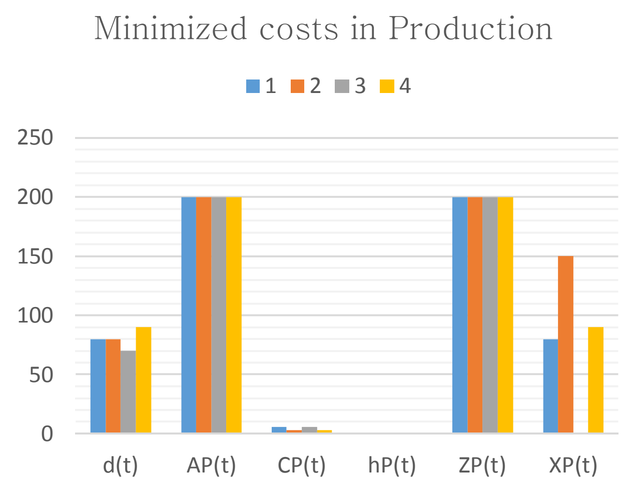

Fig.4- Bar chart for minimized costs in production

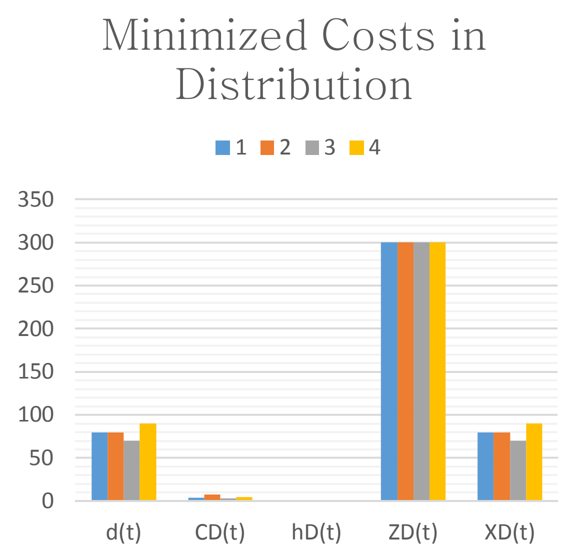

Fig.5 – Bar chart for minimized costs in distribution

As obtained results through above models supply, production and distribution the costs are not favourite therefore the experts find the results gained as following, which is the favourite result and costs as an integrated model in the process;

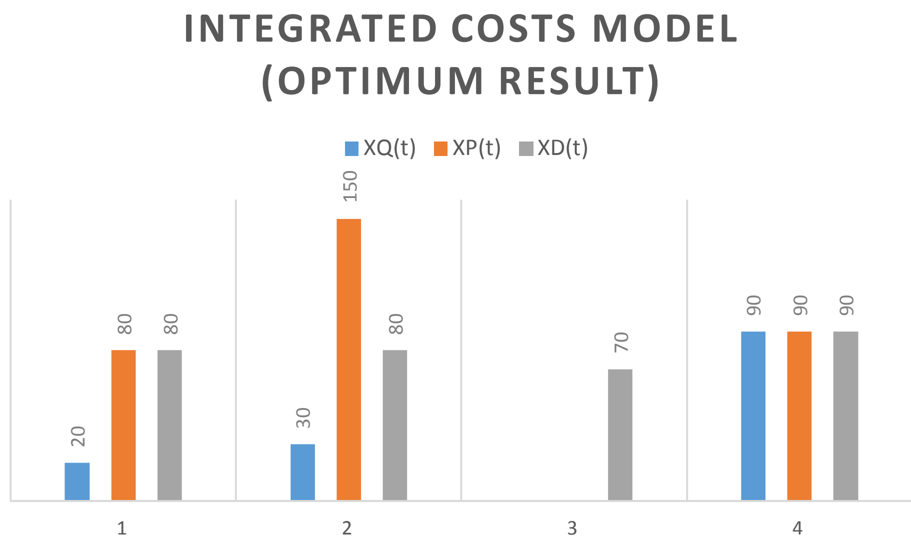

Fig.6 – Bar chart for Integrated Costs Model through the processes of Supply, Production and Distribution

Conclusion

This study deals with effective illustrate and control system of manufacturing processing flows based integrating model of supply chain levels of supply, production and distribution with Integer linear programming by considering deduction of total expenses and costs. In this regard, a total objective function is conducted to make integrated and minimizing the total costs strategically and tactically with illustrating an efficient model of supply chain systems. This includes the proper network illustrate, selection of the suppliers and capacity of the storages in order to distribute as required amount of demand and in variant quality processing by customers, even by choosing the most suitable and proper transportation methods, the procurements of stocks and the out of sales feedbacks, handling and distribution of process residue and tactical operation schedules. The unreliability of suppliers, forecast inaccuracy, lack of visibility and information or data sharing and number or variety of processes are the significant drivers or criteria. Additionally, the proposed model emphasized on the decision making districts that deals with cost-reduction approach. More specifically, by applying integer linear programming model and computational results which are performed on a real-world problem of surplus expenses and costs, to treat the problems in integrating the levels of supply, production and distribution for the goals and obtain the preferred compromise solution, integer linear programming as minimization of the costs and expenses thoroughly is employed. Once the quantity and capacity levels of the depo for the plants and storages are obtained and decision making on logistics are depended on regional plants as supply chain plan, the proposed local level model can be utilized to obtain a comprehensive progress of the local suppliers to end level of supply chain network along with limitations and lacks of transportation systems or methods for the selected storages.

Despite of it, the relevant decisions to the spatial and logistical structure of the local supply chain network, allocation of the high quality demand rate to the plants and processing flow of production, distribution to storage decisions are made through the proposed model.

To achieve the advances of the proposed integrated cost approach, competitive results are performed on a real-world problem in industrial community of Sharif in Pakdasht, Iran. The results and numerical computations of the case study reveal that the proposed and solution for the integrated total cost model can effectively be used in practice, to illustrate sustainable cost model by combining model of supply, production and distribution models based on cost-minimization approach in supply chain manufacturing system.

The final results by objective function of minimization the costs of integrated model of supply, production and distribution districts expose that, logistics demand has the biggest effect in the cost, service level, stocks and inventory storage, capacity and JIT[2] method. The proposed model and result by it is to be trialed to handle the costs logistics in supply chain design problems in various regions with different types of feedbacks and transportation modes. The model can be readily extended to include

[2] Just- in- Time

additional, case specific constraints required by the problem.

The decision makers, experts and the investors required can employ as this operational and computations terms of data in model and the obtained solution for integrating cost model in their manufacturing costs systems to achieve the most and effective model of supply chain to meet the minimized total costs optimization. The model also acquired identifying policies to support viable, profitable and reduced costs and ecosystem distributing the products industry. The framework can be applied at the company level as well for using by a single enterprise for strategic planning of its own activities under similar products.

We have proposed the modified cost models of supply, production and distribution and an integrated total cost model of internal and external logistics and also it was noted the significant criteria or indices that effects on correction of costs as integrated model. The advance development of the model is as below;

1. Some assumptions of limiting the model is including of inventory policies, number of suppliers, production centers and distribution center that came in this model is expandable.

2. Regarding the real condition of products consisting of spare and subsequent products, productive systems, vasting the supply sections, production and distribution can be developed the integrated model.

3. Regarding to the warehouses and transportation tools and allocating them can be considered.

4. In field of solving models can use Heuristic methods and or simulation.

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11/4/2017