A Mathematical Programming Model of Activity-Based Costing in order to Improve Profitability and optimal production Orders

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Abstract  
According to the system of Just-in-time (JIT), the criterion of due date is as one of the important factors in competition among manufacturing companies in that customers expect goods will be delivered to them in a specific time. The major purpose of this study is optimizing the orders at supply chain (SC). In order to maximize the profitability, Mixed Integer Programming (MIP) will be used based upon and the critical concepts such as Activity-Based Costing (ABC) and product due date have been considered. To evaluate the effectiveness of the proposed mathematical model, this model is compared with Theory Of Constraints (TOC) model based on the operating costs that would in different due dates for a manufacturing case study. The results of this study provide administrators and decision makers with appropriate solutions so that they have appropriate planning for resources optimized allocation by considering the ABC logic and maximizing profitability with fulfilling orders with more benefits.

Keywords: Activity Based Costing, Just-in-Time, Theory of Constraints, Mixed Integer Programming.

Introduction  
Management methods such as Lean management, Concurrent Engineering and JIT are employed to investigate product delivery in due dates. One of the most important of these methods is JIT. This method shows a situation in which certain quantities of goods should be produced and delivered at a certain time. But it requires the proper ordering model for proper management of the timely delivery dates. The ordering model is formed based on the commitments and demands of customers and allows the manufacturer to realize order delivery at a certain time based on the volume of demand and feasibility of production. The critical role of the order model is realizing meeting customer demand orders based on the available resources. In order to provide a possible answer to the demand of customers, the orders system should ensure that the promised orders must be delivered at the right time. Hence, a real system of orders must be able to promise orders and also must be able to execute the orders. In addition, this type of systems should be with a dynamic adaptation so that it can bring the greatest profits for the unit in order to meet demands and to be based on the prioritizing customer orders. Based on this feature, the actual orders system should be executable at an operational environment and in a short period of time. This feature makes orders systems distinct from traditional planning systems, scheduling processes and Inventory Management. Companies are increasingly competing on the variety of products and services, including available to promise and delivery time of it. Quality and costs are also as important standards for competition in the market, as far as accuracy in available to promise, speed of delivery, as well as the number of orders delivery can make orders more successful. With parallel advances in technology, production systems have moved towards a new philosophy so that they can create a strong relationship between customers and suppliers and finally form an integrated SC. In addition, the product life cycle is also steadily declining, which requires substantial and flexible order management.

Also, the traditional ordering management model has no specific commitment to finishing of existing and future products. Therefore, the key task in scheduling of such production systems is providing possible time of commitment to the customer. However, usually creating available to promise and comprehensive criteria are not considered simultaneously, and cost measures of the companies also have examined this problem less than that at when an orders can be profitable. To illustrate the difficulties imposed by this environment, order management systems require determination, measurement, reporting and analysis of information about performance and the economic activities of the companies. Such an approach provides tools to develop an economic assessment of the laws of order acceptance and schedule decisions [1]. Therefore, managers need to have integrated operational and cost models to measure and control the value of their organizations and thus be able to respond effectively to market demands. Furthermore, these models can make the investing problems more obvious for decision makers.
in technology scope. In these models assumptions that a company use with respect to the direct and indirect allocation of costs, can also be examined before the formation of the new policy. The cost of production includes the cost of materials, wage and used overhead.

If the amount of overhead is insignificant part of the cost of production, the consideration of overhead may not be so important. However, companies that maintain advanced technology production would incur costs of overhead and form a high large percentage of total production costs [2]. Today, with the development of advanced technologies in various fields and with increasing complexity and diversity of activities, understanding these changes and to assessing their effects on costs of production units would be very important. Obviously, the knowledge of the activities and measuring their effect on production unit costs would require designing a suitable costing system. A potent way to determine the exact cost information of the products is establishing ABC method. This method that is an approach of accounting and cost management strives to show existing and common defects of traditional cost accounting methods. Thus has the ability to understanding operating costs and overheads. Using ABC model increase along with mathematical models of decision support system at SC can make ABC management mechanism more transparent than other cost management and accounting tools.

Recognition and controlling costs and timely delivery dates in production units and SC is also very important for stakeholders. But to achieve this, a suitable and efficient system of mathematical programming models must be developed and identifying after the recognition and the complexities associated with the activities and right service system, can be effective in order to achieve a desirable levels of profitability in the SC. Obviously, using this method in addition to removing the problems in the SC, can also provide managers with useful information for decision-making [3].

The major aim of this study is applying a mathematical programming model along with the ABC approach for order management system in the SC. It considers profitable analysis and the basics of production planning at the same time. Finally, we introduce an analysis of the theoretical principles, available research literature related to manufacturing industries, order management and SC that include ABC methods so based on that we can provide needed background to develop and study mathematical programming model based on the ABC method.

Literature Reviews

In this study, the review of research literature relating to mathematical programming models based on the ABC would be provided in order to reveal significant SC criteria, including profitability that should be evaluated. In this regard, first, the structure of the SC and methods of information exchange would be expressed, and then performed studies in this area will be presented. A SC involves in several stages that creates added value for the product via the process directly and indirectly. Every SC consists of three main flows including the flow of information, the flow of goods and financial flows [4]. The main role of the information flow and cash flow is to facilitate material flows in the opposite direction of each other.

Financial flow is responsible for money and credit transfer in a SC. Figure 1 shows the general structure of a multi-stage SC. This chain consists of different suppliers that can provide raw materials and secondary components needed by manufacturing units and customers. The process begins by receiving a customer's order and will be continued by the purchase of raw materials from suppliers so that finally the requested product (order of customer) could be delivered.

Maximizing the profitability of each segment of the SC does not guarantee on accessing to maximizing the profitability of the entire SC. Manufacturers are always working according to the available capacities to meet profitable orders (by choosing profitable customers). They are also trying to purchase raw materials and other components and items which have the lowest cost. They also seek to supply the orders with the maximum profitability of production unit. The decision about which of the orders should be accepted and which orders should be rejected, requires an understanding of how a particular order can be profitable. Others [5, 6], have provided a useful review of the SC on coordination of production planning between the stage or stages of the SC and have had special emphasis on models which are fully associated with SC models. In this case, supply chain management (SCM) is as a key component and competitive strategy which can increase productivity, efficiency and profitability of an organization [7].

According to these models, managers in many industries are attempting to expend SCM better through the use of such techniques as JIT, total quality management, Lean Production, and computerized schedule of enterprise resource planning, ABC and kaizen. Among these techniques, ABC is one of the most important techniques for improving organizational performance and SCM [8, 9]. Lin et al. [10] by adopting a combination of ABC & SCM stated that ABC is as a complex system that can help managers for strategically important business decisions. They contend advanced that each part of the decision-making process in SCM requires distinct cost information, and the relationship between ABC and SCM is very clear. They also argued that the development and importance of the cost information in SCM will be increased by combining SCM and ABC.
In line with the importance of developing and combining ABC and SCM, a large volume of the literature have investigated to the types of partnerships that ABC can have with SCM. Among the most important factors are the costs of reduction, estimating cost, a measure of performance [11, 12]. Schulze et al. [13] also developed some models of ABC for cost accounting of the companies at SC. Their models were carried out as a basic model in a case study in one of the largest European companies. Some studies have shown a correlation that exists between ABC and other strategies to improve SCM, such as JIT, total quality management and business process reengineering [14, 15]. Novičević and Antić [16] have applied ABC as the maintenance and improvement strategies in order to optimize their benefits. Banker et al. [17] had analyzed positive impacts of ABC in compliance with a series of world class manufacturing. They concluded that, although ABC is as a successful accounting system, but its main and potential ability is still not fully used in the industry. The use of cost information in management decision-making process has been identified as one of the key topics of research in cost accounting during recent decades. The results indicate the importance of cost accounting information in decision making sections, such as price, product profitability, production against the purchase and development of the plant [18]. In cost accounting system, ABC management has been as a very practical approach in the management decision-making process of SC and shows the cost hierarchical structure in more detail. ABC management structure and cost data may be combined with mathematical models of Decision Support System. In this regard, Gupta and Galloway [19] introduced ABC as an information system of decision support for operational processes such as product planning, product design, quality management, process design, process improvement, Inventory and Investment Management.

In the case of ordering and the amount of promising to complete the order, as it is clear in material requirement planning, delivery time and the value of an order to customer is created based on the logic of promise. The main idea behind the concept of promise value is that predicted values of the actual orders should be estimated based on the master production schedule. For example, orders can be estimated by the present inventory. So the key activities of schedule for production control in such production system will cause time commitment to the customer [20]. Vollmann et al. [21] have proposed a basic review along with application of this technique. McCelland [1] also studied this concept for the make to order environment and concluded that even if simple techniques for the allocation of capacity and material requirements, when the main schedule of production is used for preparing orders, can increase percentages of received and provided orders. Taylor and Plenert [22] presented a heuristic technique for Finite Capacity Promising (FCP) and to provide possible delivery times for customer orders commitment. They stated that identifying lack capacity provide the marketer with details on which they can provide possible production schedule and as a result of the actual times of meeting the orders and focus on the sale of idle capacity. Their model does not include costs associated with the production and profitability but rather has focused on understanding the limitations of the existing processes and balancing materials at the SC and for meeting customer needs. Hariharan and Zipkin [23] also evaluated the impact of data for customer orders and due date on the basis of policies adopted in potential models. Surowiec [24] presented a review of cost methods to manage SC and emphasized the key role that management accounting information can be used in SCM. It identifies key methods that can be used in practice for the implementation of management accounting tasks to finally create effective SCM. In the field of mathematical modeling, Degraeve and Roodhooft [25] also provided a mathematical modeling approach to provide services in the SC and using ABC. In this model, they referred investigating selection of suppliers for various orders within a specified time period. Jafarnejad et al. [26] presented a mathematical model of the SC order management based on the approach to optimize and ABC structure and studied the optimum combination of orders in the SC and in different decisions conditions of uncertainty. They used simulation to evaluate the results, and showed the model validation and estimating the order portfolio and developed different scenarios. In another study Jafarnejad et al. [27], investigated selection of the best combination from incoming orders in the SC as well as determining the exact costs of an order by offering a weighted goal programming approach and studied the problem in two steps that in the first stage determined optimized combination of orders in SC by using a mathematical optimizing approach and in the second phase examined costs of orders using system dynamic approach, and showed that ABC approach at SC orders is more efficient than approach of the traditional costs.

Shapiro [28] also widely analyzed ABC usefulness for strategic decisions. He concluded that ABC is capable of responding in generalizing previous costs and related expenses that are valuable for strategic decisions and principles of the planning. Accordingly, he presented a mathematical model based on ABC, according to which the production unit may be closed or sold during the studied period. Kee [29] also offered a model of MIP to determine the optimum combination of the product in the assessment of costs, physical resources of production and market demand at the same time. In this model, he used ABC logic model based on the use of homogeneous cost pool presented by Cooper and Kaplan [30]. Cooper and Kaplan provide a framework for the production costs for overhead costs, and it is divided into four types of specific costs:

1) The cost of the activities of the Unit level (machining time, materials, direct labor, etc.) that is directly related to the number of produced units.
2) The cost of batch level (planning and tactical management, material handling, setup, etc.) that occurs during a mass of productive activity.
3) The cost at the product level (the orders level) Activities (process of engineering, design, etc.) that have been made at time of the production of a certain product (customized).
4) The facility cost of maintaining activities such as rent, utilities, maintenance and management features.

**ABC Mathematical Programming Model**

In preceding literatures of the ABC and related to demand management and fulfillment of orders and profitability of each individually, only a limited set of criteria have been
considered. In none of the indicated studies, such important criteria as due date, earliness and tardiness penalty and the proper sequence to produce products in each period that is critical in order to optimize and maximize profitability has not been yet considered. Hence in this study an attempt will be made to show all these issues in the form of a mathematical programming model of ABC.

In this section, mathematical programming model based on the ABC logic is offered. In this model, the overhead costs are calculated among the based upon Cooper and Kaplan [30] model of unit, batch and order levels. It is noteworthy that the facility cost of maintaining of activities has been calculated equally between products. In this way it will not affect the results of the model. Here the MIP model will be used to evaluate costs of various levels of ABC with the sections of acceptance and rejection of orders and also sequences and schedules of products for production at each period along with considering the logic of JIT and due dates of the products. Then, the variables of decision, indices and input parameters will be introduced to specification of the present ABC-MIP model.

Model Variables:

$S_{it}$: The number of sales of the product $i$ in order $o$ at the time period $t$.

$P_{it}$: The number of produced product $i$ in the time period $t$.

$B_{ij}$: The number of product sets $i$ produced under the activation $j$ at the time period $t$.

$Y_{iot}$: Product $i$ in order $o$ in time period $t$ is accepted or rejected for production.

$E_{ij}$: The amount of earliness time of the produced product $i$ in the time period $t$.

$L_{ij}$: The tardiness time of product produced $i$ during a period of time $t$.

$M_{it}$: Starting time for producing product $i$ at the time period $t$.

$M_{ht}$: Starting time for producing product $h$ at the time period $t$.

$X_{ith}$: The sequence of processing products $i$ and $h$ in the time period $t$.

In the preceding variable, the following definitions were adopted:

$i, h$: Product $o$ : order

$t$: Time period $j$: activity of unit level

$v$: Supplier $l$: activity of order level

$k$: Batch level activity $r$: Raw Material

Model Parameters

$P_i$: Price of sale of product $i$.

$a_{ij}$: Earliness cost of unit related to product $i$ at time period $t$.

$\beta_i$: Tardiness cost of unit related to product $i$ at time period $t$.

$d$: Due date of product during each time period.

$g_{ir}$: The consumed resource value $r$ for each unit of product $i$.

$c_{ir}$: Cost of purchased resource unit $r$ from supplier $v$.

$x_{ij}$: Unit cost rate for doing activity $j$ at unit level (according to labor and run time).

$a_k$: Unit cost rate for doing activity $k$ at batch level (according to batch setup time).

$u_{ijk}$: Applied setup time amount for activity of batch $k$ related to activity of unit level $j$ for product $i$.

$y_{il}$: Unit cost rate by means of each activity $l$ at order level.

$F_l$: Applied time by activity $l$ for producing product $i$.

$R_{ri}$: Maximum raw material available of $r$ by supplier $v$ at time period $t$.

$Q_j$: Total of available time to complete activity $j$ at time period $t$.

$b_i$: Size of product batch $i$ produced under activity $j$.

$U_{kl}$: Total of available time to complete activity $k$ at time period $t$.

$D_{it}$: Product demand amount $l$ at order $o$ at time period $t$.

$q_{ij}$: Amount for resource (run hours) used by activity $j$ related to produce one unit of product $i$.

So based on the preceding variables and parameters, proposed ABC-MIP model is shown as follows:

$$\text{Max } Z_{ABC} = \sum_i \sum_o \sum_t p_i S_{it} - \sum_i \sum_o \sum_t a_{ij} E_{ij} - \sum_i \sum_t \sum_l \beta_l M_{lt}$$

$$- \sum_i \sum_j \sum l q_{ij} P_{it}$$

$$- \sum_i \sum_j \sum k a_{ik} B_{ijt}$$

$$- \sum_i \sum_j \sum k \sum r \sum v a_{ik} B_{ijt}$$

$$- \sum_i \sum_j \sum l \sum r \sum v g_{ir} c_{ir} Y_{iot}$$

$$+ \sum_M \sum_j \sum l \sum r \sum v g_{ir} c_{ir} P_{it}$$

$$\text{St:}$$

$$M_{lt} + \sum_j q_{ij} P_{it} + \sum_k u_{ijk} B_{ijt} - \sum_l f_{il} Y_{iot} - d \ll L_{it} ; \forall i, t$$

$$d - M_{lt} - \sum_j q_{ij} P_{it} - \sum_k u_{ijk} B_{ijt} - \sum_l f_{il} Y_{iot} \ll E_{it} ; \forall i, t$$

$$M_{an} + \sum_j q_{ij} P_{it} + \sum_k u_{ijk} B_{ijt} + \sum_l f_{il} Y_{iot} \leq M_{an} + R(1 - X_{iht}) ; \forall i, h, t$$

(1)

(2)

(3)
Comparing ABC and TOC Models

In order to demonstrate the efficiency of the profitability ABC model, proposed model will be compared with TOC model by using an actual manufacturing case study. TOC is a combination of operational strategy. This technique is a combination of several tools that are designed to improve the performance of the company. The purpose of individuals that introduced and developed this technique was to present a method to increase the business unit’s financial performance. This technique seeks to achieve organizational goals through a simple multi-step process, but very powerful considering resources with highest constraints. TOC that is an innovation of the 90s, in the short term can help managers to achieve the maximum benefits of the company. TOC is a management system philosophy developed by Golderat. In his book entitled “The goal: to improve a process is running,” he argued that the company’s aim is to generate monetary resources now and in the future and the company cannot survive without these resources. So any activity that does not help enhancing the funds, is considered as a waste of resources and a waste of time [31].

In ABC, planning is considered for a long-term time, while TOC focuses on to short-term time [32]. Short period corresponds with a period of time that one or more of the resources used in the production process are fixed. Therefore, in the short term the company’s capacities and the costs associated with identified capacities (including direct labor costs and overhead) are fixed, this fixed capacity creates bottleneck. In such circumstances, the only costs that can vary, is the cost of materials and as a result the short-term decisions should focus to make the most profits from these constraints. On the other hand, at long-term decisions, ABC seems more logical, because it provides a long-term vision of the costs that can be changed by business decisions. In addition, TOC standards will lead managers to the limited capacity, so the maximum capacity of the bottleneck is considered. But ABC focuses on excess capacities and by allocating excess capacities to factors responsible for cost management, they would encourage managers to eliminate unnecessary capacities [33].

TOC model in this paper is based on the common model provided by Noreen et al. [34] that based on it the obtained reasonable profit is calculated as follows:

\[
\text{Profit} = \text{Throughput} - \text{Operating expenses}
\]
In this formula, throughput includes revenue from sales minus the cost of raw materials consumed. Due to these two important approaches of accounting, the purpose of this study has been adoption and implementation of the ABC-based model presented in the previous section to describe the physical characteristics and process flow of a business and act as a tool for the management of orders and by considering profitability and simultaneous production planning decisions and results of its performance to be compared with the mathematical programming TOC formulation. These results provide a framework for the simultaneous use of order management and profitability analysis and can also help managers to consider an appropriate model for their business environment. In addition, the use of the model can also provide other benefits. First, with regard to capacity during the planning process one can get more realistic dates than the traditional ways to meet the demand. These improved commitment dates lead to a better implementation of the product delivery times and thus can help companies in different situations. Through further negotiations related to due dates of the order and the reject of an order when the necessary resources are not available to meet customer demands, one can increase customer service levels. Second, determining the unused capacity can increase company’s attempt to sell products that can take advantage of this capacity.

Computational Results

In order to provide numerical numbers, Farasan Industrial Co. was selected as a case study. Farasan Industrial Co. is leading in transferring of GRP pipes technology and distributing them to various industries. It is one of the largest manufacturers of various types of pipes in Iran. In this section, a problem including 4 orders for 4 different products and at 5 time periods (months) are presented to analyze the performance of various aspects of this model. Also related operating parameters are provided. In this study, a system of production based on the demand which consists of four different types of suppliers, is used for production of various types of couplings. Each supplier has a capacity of 9000 to 38,000 kilograms of raw materials for a variety of raw material of resin, chop, Hoop and sand in each period. Also to optimize the orders based on due times during different periods penalties of delays in production and delivery of products will be considered. In this study, the time is considered as Cost driven. Use of time structure as a major driver of costs for this issue will have a lot of advantages as follows:

- It removes one of the complex stages at the conventional ABC method, i.e. cost allocation of resources to activities, at first stage.
- Most of the important sources of a circle (the organization), such as staffs and equipments, have capacities that their availability rate to complete project is measurable by time structure. Thus Time Driven Activity Based Costing (TDABC) facilitates measurement of the desired capacity and makes it easy to create an equation in terms of time to summarize its subsets in an equation [35].

Consequently in this study, information related to activates of the unit level, batch level and the level of orders were obtained based on the time (minutes) needed to produce each of the four products. Table 1 shows relevant information.

| Table 1: Time of unit of activities at unit, batch and order|
|----------------|----------------|----------------|----------------|----------------|
| Product        | Unit activities | Batch activities | Order activities | Order activities |
|                | time (minutes)  | time (minutes)  | time (minutes)  | time (minutes)  |
| P1             | 11              | 8               | 6               | 3.5             |
| P2             | 7               | 5               | 4               | 4.5             |
| P3             | 10              | 6               | 5               | 9               |
| P4             | 9               | 4               | 9               | 9               |

To produce each group of products, each of these groups are completed and equipped by a machine so that they are distributed in each period according to the request related to orders and then the next groups of products are equipped and completed on the same machine. It should be noted that accepting of some orders may not be profitable for the production during a period so this problem also has been considered at restrictions of the mathematical presented model. To demonstrate the effectiveness, we compared our proposed model with respect to the information of the factory model which is based on TOC. ABC-based model was calculated by software Lingo, version 8 and 4 Pentium computer with 4 GB of RAM and CPU power GHz 2.67 for different due dates. Computational time in this model is on average less than ten seconds. Table 2 shows plant operating expenses and improved profits from ABC and TOC models based on different due dates that are a multiple of thousand. It should be noted that one of the distinguishing features of this ABC-MIP model is its ability to show the starting time of each of the products, the optimal sequence of production of products group in each period, the amount of early and tardy time of the products during each period. Profit is obtained from the TOC model of equation (15) and profits from ABC model has been made by the formula $Z_{ABC}$.

To analyze the data, and the choice of relevant tests type for statistical significance, first the normality status of variables must be checked; because if variables are normal, parametric and nonparametric tests can be utilized. But if the variables are not normal nonparametric tests can be employed. In this study Kolomogrov-Smirnov test (KS) was utilized. This test was to be used when we want to see variable data are normal or not. If significance level is more than 0.05, null hypothesis based on normality of the data is accepted. Table 3 illustrated the result of the normality test. Therefore, the following statistical assumptions are evaluated:
Null hypothesis: Data follow with the normal distribution.
Alternative hypothesis: Data do not follow with the normal distribution.

Table 2: Comparing the obtained profits of ABC & TOC models.

<table>
<thead>
<tr>
<th>Due Date</th>
<th>ABC Model</th>
<th>TOC Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Obtained Profitability</td>
<td>Operating Expenditure</td>
</tr>
<tr>
<td>6.5</td>
<td>64744150000</td>
<td>23421000000</td>
</tr>
<tr>
<td>7</td>
<td>64414630000</td>
<td>23421000000</td>
</tr>
<tr>
<td>8</td>
<td>64556900000</td>
<td>23421000000</td>
</tr>
<tr>
<td>8.5</td>
<td>64033610000</td>
<td>23421000000</td>
</tr>
<tr>
<td>9</td>
<td>64863441000</td>
<td>23421000000</td>
</tr>
<tr>
<td>9.5</td>
<td>64976550000</td>
<td>23421000000</td>
</tr>
<tr>
<td>10</td>
<td>65080580000</td>
<td>23421000000</td>
</tr>
<tr>
<td>11</td>
<td>65080580000</td>
<td>23421000000</td>
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<tr>
<td>11.5</td>
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<td>23421000000</td>
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<tr>
<td>12</td>
<td>65080580000</td>
<td>23421000000</td>
</tr>
<tr>
<td>13</td>
<td>65080580000</td>
<td>23421000000</td>
</tr>
</tbody>
</table>

Table 3: Normality test of the variables of the study.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Kolomogrov-Smirnov</th>
<th>Sig</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obtained Profitability (ABC)</td>
<td>0.309</td>
<td>0.990</td>
<td>Normal</td>
</tr>
<tr>
<td>Obtained Profitability (TOC)</td>
<td>0.855</td>
<td>0.498</td>
<td>Normal</td>
</tr>
</tbody>
</table>

According to Table 3, Kolomogrov-Smirnov test values and sig value have been stated for both studied variables, as it is observed that for both variables studied sig value is more than 0.05 and the null hypothesis is not rejected as a result, data for both variables is normal. To examine the differences between the average profits of two models paired t-test is used because of normality of data and therefore the following hypotheses will be provided:

Null hypothesis: the average profits of ABC and TOC models are the same.

Alternative hypothesis: the average profits of ABC and TOC models are not the same.

In Table 4 to assess the significance difference between average profits from the ABC model and average profits from the TOC model, the paired t-test was used that with respect to the amount of t (76.423), its significance level is less than 0.05 (0.000), which indicates the difference between average profits from the ABC model and average profits from the TOC model; and according to the calculated averages, the null hypothesis is rejected and the conclusion is that the ABC model average profits is more selective for order management system than the TOC model average profits.

Table 4: Average profits of ABC& TOC models.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Number</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obtained Profitability (ABC)</td>
<td>0.048971497</td>
<td>12</td>
<td>1.2332494.80</td>
</tr>
<tr>
<td>Obtained Profitability (TOC)</td>
<td>0.010924500</td>
<td>12</td>
<td>0.527289.312</td>
</tr>
</tbody>
</table>

Table 5: Paired-Samples T test.

<table>
<thead>
<tr>
<th>Obtained Profitability (ABC)</th>
<th>t</th>
<th>df</th>
<th>Sig (2-tailed)</th>
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</thead>
<tbody>
<tr>
<td>Obtained Profitability (TOC)</td>
<td>76.423</td>
<td>11</td>
<td>0.000</td>
</tr>
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</table>

Conclusions and Recommendations
In this paper, a model of MIP based on the ABC was evaluated to optimize orders and maximize profitability with respect to the actual order system and logic of JIT. Model constraints include available capacity for raw materials and the time available for unit level activities, batch and order levels. The results of this research are to meet the demands are profitable for production unit plant with respect to ABC logic. Numerical results showed how the propose model simultaneously consider the three main goals: Proper realization of profitable orders in full, realization of logic due date for delivery of products to customers, according to the logic of tardiness and earliness penalties and to maximize profitability. Also, the fact that in the mentioned cases, the ABC based model produced higher average profits than the TOC model for different due dates was shown. It is recommended that the model presented in this article to be developed for states that the demand of periods is also probable in future studies. The conditions that were studied in this research had about a production case to complete and equip the products by only a machine. Therefore, it is suggested that in the cases that the production unit for the evaluated issue has more than one machine, such as parallel, flow or combination states, should be examined.
Acknowledgements
Here's the place to appreciate Farasan industrial manufacturing company that provided production and financial information related to the selected products to solve and compare the models.

References


