The effect of the theory of constraints on measuring the efficiency and effectiveness of production

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Abstract :

Establishments are exposed to many weaknesses that limit their ability to achieve throughput, so measuring production efficiency has a major role in determining the constraints facing the facility, especially concerning production processes and working to address them to improve its overall performance. The research problem is represented in the following question:-

Do the constraint that occurs in the production process cause a decrease in the efficiency and effectiveness of production in the facility?

The research aims to show the effect of the theory of constraints in measuring the efficiency and effectiveness of production for the facility, in addition to clarifying some of the constraints that cause low efficiency and effectiveness.

To achieve the above objectives, the research was applied in the South Refineries Company / Basra Refinery. The research concluded that the constraints that cause a halt in the production process must be addressed, in addition to continuously measuring production efficiency using throughput indicators to discover the constraints that cause weakness in the performance of the facility

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The first topic: research methodology

Most of the facilities suffer from several constraints that appear in the form of weaknesses that cause stoppages in the production lines, thus the production capacity is not well utilized by the facility, which results in a decrease in production efficiency, so some methods or methods must be used to determine these constraints.

First: the research problem

The research problem is represented in the following question-:

Do production process constraints cause a decrease in production efficiency and effectiveness?

Second: the research objectives

The research aims to clarify the role of the theory of constraints in measuring the efficiency and productive effectiveness of the facility, as well as clarifying the constraints that occur in the production process.

Third: the importance of research

The importance of the research is that it deals with one of the cost management tools that identify the constraints that cause low production efficiency.

Fourth: the research hypothesis

To reach an answer to the question of the research problem, the research hypothesis can be formulated as follows:

The theory of constraints contributes to the measurement of efficiency and productivity effectiveness.

Fifth: Research Methodology

The research depends on the scientific method, which combines theory through reading books and Arab and foreign scientific research, and application by collecting data and financial information necessary to solve the research problem.

Sixth: Research community and sample

- The research community is represented by the industrial sector in Iraq.
- The research sample is represented by one of the industrial sector companies represented by the South Refineries Company / Basra Refinery

The second topic: the theoretical side of the research

The theory of constraints is one of the modern and most effective management philosophies in the manufacturing and service fields, which helps to identify and address the constraints and bottlenecks that occur in the production process. From bottlenecks and work to address and increase its production capacity and then increase its profitability, it seeks to maximize the profitability of the enterprise as a whole by increasing the use of available resources.

First: the concept of the theory of constraints

The theory of constraints is defined as a procedure for managing factories and production processes and making organizational decisions that represent constraints in the first place, and it is a business management tool

that links all manufacturing techniques, and represents a practical methodology that makes it possible to infer it to solve problems regardless of their size to emphasize the process of continuous improvement(Pozo,2012:22), And management can help reduce the production cycle, as it indicates that the rate of flow of goods during the production process cannot be faster than the slowest constraint in the stage (Kinney,2011:809), It is a management philosophy that focuses on the weakest link in the production chain, with the aim of improving the performance of the facility (Simist,2014:930), All establishments may be exposed to suffocation in production processes for certain reasons that limit their ability to generate profits, and since the establishment is based on a set of successive and successive functions to provide a valuable product to the market, so these functions can be expressed in the Value Chain, so one of the most important roles that Value chain management practice is to identify bottlenecks by applying the theory of constraints (Weygandt,2012:897),And that the performance of any process or event depends on the previous event or process, meaning that it is

not possible to start a new production stage until after the completion of the previous stage(Groop,2012:28).

Second: the types of constraints

The constraint is defined as anything that prevents us from getting more of what we want. Every individual or facility is subject to at least one constraint (Noreen,2011:15), The constraint differs from a bottleneck, as the latter occurs during the production process when the work to be performed exceeds the available energy (Horngren,2012:686). The constraints facing establishments are divided into two groups, as follows:

1. **Internal constraints**

They are restrictions that limit the firm's ability to meet the demand for its products, and they are divided into two types

a. **Production constraints**

This type is one of the most important constraints imposed on the production process, represented by machines and equipment, people, and any other tangible resources. This constraint appears when the entry outputs are unable to meet market requirements (Majercak&Majercakova,2013:53)

b. **Policy constraints**

These constraints are among the most difficult constraints to discover, because they have a long-term and invisible effect and arise as a result of the application of some policies in the facility, such as adherence to a certain rule, in addition to that these constraints control a certain rate of production, such as the policy of no overtime.(Reid,2010:499).

2. **External constraints**

It is a set of constraints imposed on the facility from external sources, and these constraints are divided into two types.

a. **Supply constraints**

They are constraints in terms of production, the reason for the constraint may be the unavailability of raw materials, which is the result of external factors, for example, the presence of constraints that limit the import of some raw materials (Kershaw,2000:4)

b. **Demand constraints**

They are constraints in terms of sales, which are represented in the imbalance between the production of the facility and the market demand for its products, in other words, this constraint results when the market demand is less than the production capacity in the facility, as the facilities do not want to accumulate inventory (Reid,2010:499)

Third: the assumptions on which the theory of constraints is based

There are a set of assumptions on which the theory of constraints is based. These assumptions are as follows:

The first assumption: Maximizing the profits of the establishments

According to the theory of constraints, the main objective of the enterprise is to obtain funds, in the sense of increasing the margin of throughput to the maximum extent possible, then reducing the volume of inventory and reducing operating costs in the short term. (Horngren,2012:686)

Second Assumption: There is at least one constraint that limits the ability of establishments to achieve their goals.

The theory of constraints assumes that the performance of any system is limited by the constraints it faces and that any system should contain at least one constraint as a factor that limits its ability to achieve its goals. Therefore, these constraints are the controlling factor in the outputs of the system. It also considers the system as an interconnected series of Processes and each system is determined by the strength of the weakest link in the chain that limits the performance of the chain as a whole (Hansen et.al.,2009:779)

The third assumption: the emergence of a new constraint

The theory of constraints assumes that after strengthening the weakest link, other weaker links will appear than the first link, which will be the main constraint in the system that must be strengthened to improve the overall performance of the system (Hansen et.al.,2009:776)

Fourth: The steps of the theory of constraints

The theory of constraints focuses on a set of steps to increase throughput and improve performance. The five-step process of continuous improvement depends on finding obstacles or constraints in the system. These steps are as follows:

1. **Define system constraints**

Any facility contains a set of constraints that cause a decrease in its productivity and that constitute an obstacle to management that limits the achievement of its goals, so it is necessary to identify these restrictions and work to address them and reduce their effects through a set of measures taken by the management in integration with the

unrestricted resources to Eliminate constraints and avoid bottlenecks for unconstrained resources resulting in the formation of a new constraint (Aghili,2011:13)

2. Determine how to exploit constraints

The second step represents the optimal use of bottleneck resources, as it requires the facility to manufacture products with a higher return on completion per unit produced in the restricted center. (Jiambalvo,2010:264) And the report is done on how to exploit the restriction and make sure that no time is lost in the restricted resource, as the energy of the restricted resource should be exploited at 100%, as the loss of an hour in the restricted resource leads to the loss of an hour in the production system as a whole. (Gorczyca,2011:93).

1. Arrange everything else according to the previous decision

According to this step, anything else is subject to the previous decision, as it requires the management of the facility to focus its attention on improving the restricted resource and not on improving the production process as a whole or the unrestricted resources. (Jiambalvo,2010:265) And this step aims to not produce the unrestricted resources above what can be produced in the restricted centers, because the increase in the outputs of the unrestricted centers leads to an increase in inventory and does not lead to an increase in the margin of throughput. (Horngren,2012:687)

2. Breaking the constraint

If the previous steps are implemented and the constraint still exists, the administration should follow new methods to break the restriction. This can be achieved in several ways, such as contracting additional labor from external sources or purchasing additional equipment(Gorczyca,2011:93).

3. If the constraint was broken in the previous step - go back to step No. (A)

This step represents support for the continuous improvement process, when the energy of a certain constraint is raised to a degree where it is no longer a constraint, it is natural that a new constraint will appear, so you must go back to the first step and start addressing this constraint(Groop,2012:41-42). The completion of all the previous steps will lead to a continuous process of improvement, in addition to changing the nature of the constraints or bottlenecks, and in the manufacturing environment, for example, the constraint may change from being a physical constraint within the factory to insufficient market demand or the facility policy that must be changed (Sale,2013:109).

Fifth: productivity efficiency

Productivity is defined as a measure used to measure the volume of inputs to verify the volume of outputs. The objectives of measuring productivity include technology, efficiency, real cost savings, measurement of production processes, and standards of living.(Manual,2001:11-12) Whereas, efficiency means achieving a large amount of production with the lowest possible input and at the lowest possible cost (www.almaany.com).The higher the production efficiency, the higher the ratio of output to use of resources (Borowiecki,2013:95).efficiency defined that is the amount of output per unit of input(Hashim,elt:2023:5)

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Sixth: Guidelines for Improving Work Productivity

Many principles underpin improving work productivity(Attar et al.,2012:14)

1. Properly train the workers

2. Systematic workflow

3. Systematic planning of funds in advance

4. Make the most of the machines and automation system

5. Advance planning for equipment.

Seventh: The practical aspect

throughput and productivity will be measured according to the theory of constraints on the financial and cost data of the study sample (South Refineries Company) for the following four years 2018, 2017, 2016, and 2015 and the difference between them are explained as follows:

Table (1)

represents the throughput margin measured at the level of the company as a whole, as follows:

Year	Sales revenue / million dinars	Cost of direct materials / million dinars	Throughput margin	Throughput margin to Sales Revenue Ratio
2015	1,093,480	689,350	404,130	%37
2016	1,118,279	649,825	468,454	%42
2017	1,316,371	612,447	703,924	%53
2018	1,363,562	596,776	766,786	%56

Table (1) was prepared through the following equations

1. throughput margin = Sales Revenue - Cost of Direct Materials

2015:　　　1,093,480　-　689,350　=　404,130

2016 :　　　1,118,279　-　649,825　=　468,454

2017:　　　1,316,371　-　612,447　=　703,924

2018:　　　1,363,562　-　596,776　=　766,786

2. throughput margin Ratio = throughput margin / Sales Revenue x 100

2015:　404,130　/　1,093,480　×　100　=　%37

2016:　468,454　/　1,118,279　×　100　=　%42

2017:　703,924　/　1,316,371　×　100　=　%53

2018:　766,786　/　1,363,562　×　100　=　%56

It is evident from the above table that the completion margin for the four years has increased as a result of relying on the cost of direct materials only.

overall productivity

Production efficiency can be measured through the surplus of operations to production requirements, where production requirements are commodity requirements and service requirements.

Table (2) shows the productive efficiency at the company level, as follows:-

year	Surplus of current operations	production supplies	production efficiency
2015	173,039	734,337	%24
2016	240,871	685,470	%35
2017	462,749	651,924	%71
2018	495,273	644,571	%77

Production efficiency was calculated through the following law:

Production efficiency = surplus of current operations / production inputs x 100

2015:	173,039	/	734,337	×	100	=	%24
2016:	240,871	/	6,854,707	×	100	=	%35
2017:	462,749	/	651,924	×	100	=	%71
:2018	495,273	/	644,571	×	100	=	%77

We note from the above table that the production efficiency for the year 2016 decreased significantly, as it represented 4% compared to other years. This indicates the inadequacy of the surplus of operations achieved by the company in that year with the costs of production requirements. However, in the last two years, the production efficiency rate has increased significantly. This rise is due to the reduction of costs represented in production and service requirements.

Limitations in the production process

After studying the production processes in the company under study, it was found that there are a set of restrictions that cause pauses in the production process due to the obsolescence of production units. These restrictions can be summarized in the following table Which represents the total stops for the year 2018:

Section	operational unit	2018	
		Number of days off	Number of production days
Basra Refinery / 1	refining/1	25	340
	hydrogenation/1	28	337
	Petrol improvement/1	85	280
Basra Refinery / 2	refining/2	7	358
	hydrogenation/2	25	240
	Petrol improvement/2	86	279
Basra Refinery / 3	refining/3	7	358
	hydrogenation/3	26	339
	Petrol improvement/3	33	332
Fats	Vacuum Distillation Division	360	5
	Wax removal division	365	-
	Farfral Division	365	-
	Asphalt removal division	365	-
liquid gas division	gas/1	24	341
	gas/2	29	336
	gas/3	9	356

The above table shows a set of constraints that cause a decrease in production efficiency, so the company must address these constraints and start with the longest downtime to improve that unit. It was also noted that the fat refinery has been completely stopped, as this refinery works on the production of asphalt only with a production capacity of 1000 tons/year, and stopping this refinery means a waste of production capacity, so work must be done to restart these units to raise the production capacity of the company, which returns benefit to it. The company also has two types of plants, the drums factory, and the plastic containers factory, which are also suspended. The production capacity of each factory is 400 barrels/hour and 1100 cans/hour, respectively. It can be restarted and used instead of importing these materials for packaging.

The following table shows the actual production capacities compared to the plan, available, and designed ones, as the production capacity represents the company's ability to produce outputs for a certain period. The basis for determining the available capacities is the efficiency of the equipment of the operational units and the availability of spare materials for them.

Products	production capacities			Actual production		% energy utilization	% Efficiency in Planning	% Efficiency in Planning	% development of production
	Design	Available (2)	Planning (3)	2018 (4)	2017 (5)				
	(1)	(2)	(3)	(4)	(5)		(3/2)	(4/3)	
Gasoline/m^3	1,591,397	1,854,517	1,951,450	1,916,700	1,854,517	%103	%105	%98	%3
White oil / m^3	1,276,953	850,528	609,750	777,528	850,528	%91	%72	%128	(%9)
Gas oil/m^3	1,741,900	1,765,555	1,944,800	1,596,843	1,765,555	%90	%110	%82	(%10)
fuel oil/m^3	5,639,966	5,404,801	5,610,500	5,293,294	5,404,801	%98	%104	%94	(%2)
Jet fuel/m^3	1,276,953	850,528	609,750	777,528	850,528	%91	%72	%128	(%9)
liquid gas/ton	211,200	93,333	127,925	122,200	93,333	%131	%137	96%	%31
light naphtha/m^3	564,107	381,328	-	528,103	381,328	%138	%0	%0	%38
heavy naphtha/m^3	1,651,555	2,035,259	-	1,713,924	2,035,259	%84	%0	%0	(%16)
asphalt/ton	150,500	10,600	6,975	-	10,600	%0	%66	%0	%100)(

The percentages were calculated in the above table according to the following equations:

Energy utilization rate = actual production for the year 2018 / available production capacity x 100

Gasoline: 1,916,700 / 1,854,517 × 100 = %103

Planning Efficiency Ratio = Planned Production Capacity / Available Production Capacity x 100

Gasoline: 1,916,700 / 1,854,517 × 100 = %105

Efficiency ratio in planning = actual production for the year 2018 / planned production capacity x 100

Gasoline: 1,916,700 / 1,951450 × 100 = %98

Production development rate = (actual production in 2018 - actual production in 2017) / actual production in 2017 x 100

Gasoline: (1,916,700 - 1,854,517) / 1,854,517 × 100 = %3

The same equations are used above for other products

We note from the previous table that the ratio of efficiency and effectiveness in planning is inaccurate for some products due to the planned energy exceeding the available energy, as the latter affected the percentage of energy utilization for some products because the actual production is greater than the available energy, which leads to the use of machines more than their normal capacity, This results in an increase in inventory on the one hand, and greater consumption of machines, which leads to many stops and holidays and thus stops production lines on the other hand.

We also note that the deviation from the design capacity is due to the lack of qualified production units, the lack of sufficient reserve materials, frequent power outages, the lack of sufficient maintenance periods, as well as the high percentage of salinity and mechanical failures.

We also note that the rate of product development in the company compared to 2017, is low, and this confirms the restrictions that were clarified in the table of the total stops that affect the efficiency and effectiveness of the company's operation.

Conclusions

1. The theory of constraints adds a new dimension to the philosophy of management. Contribute to achieving many goals, including continuous improvement.

2. The constraint represents the controlling factor in the outputs of the system, these outputs are how profits are maximized, therefore they are produced according to what is specified, and this requires the exploitation of the constraint effectively to eliminate the obstacles that cause the outputs not to be provided according to what is planned.

3. The company suffers from a set of restrictions represented by the stops that caused the suspension of some production lines and which led to a decrease in the production capacity of some products.

4. The increase in the margin of achievement compared to 2015, indicates that the company can achieve its goals, the most important of which is increasing its profits by rationalizing its costs.

5. The production efficiency decreased in 2016 by 4% compared to other years as a result of the inappropriateness of the operations surplus (net profit) achieved by the company with the costs of production inputs.

6. The actual production of some products is higher than the available energy as a result of improper planning. Where the planned energy exceeds the available energy, which leads to the use of machines more than their capacity, which increases inventory and consumption of equipment and machines, in addition to many stops and holidays.

7. There are many vacations during the year.

Recommendations

1. Work according to the philosophy of constraints theory because it provides better standards and more accurate information for planning and making correct administrative decisions.

2. .Reconsidering the classification of the cost structure in line with the modern manufacturing environment.

3. .Relying on the philosophy of the theory of constraints to identify the constraints that impede the company's performance and work to treat them first in order not to exacerbate problems in it.

4. The need to rehabilitate the fat refinery and the two factories for manufacturing plastic barrels and containers to raise the production capacity of the company.

5. The necessity of expanding the outlets for marketing the products, at least locally, because marketing the products only to the Oil Products Company / South Branch and the Gas Filling Company is one of the reasons for increasing the stock.

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