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The role of sustainable constraints theory in reducing production costs in industrial economic units: An Applied Study at the Kufa Cement Plant in Najaf Ashraf Governorate

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Abstract

The research aims to study and analyze the role of the Theory of Sustainable Constraints in reducing production costs in industrial economic units. The problem of the research is that profit-oriented industrial economic units face numerous issues in their production processes, which consequently leads to increased costs. Relying on traditional techniques or methods is accompanied by many deficiencies, in addition to the internal and external constraints that management faces, which affect the efficiency and effectiveness of resource utilization, competitive capacity, and profit maximization. To achieve the research objective, a case study of the Kufa Cement Plant was conducted by identifying the constraints imposed on production processes that cause cost increases and how to manage and eliminate them to reduce the associated costs. The researchers concluded that the Theory of Sustainable Constraints plays a very important role in assisting economic units in reducing their production costs by identifying production constraints, focusing on resolving them, and maximizing resource utilization efficiency in the best possible way, which contributes to cost reduction and profit realization.

Keyword: Sustainable constraints theory, cost reduction production

Introduction

The process of cost reduction and control presents a significant challenge for management in industrial economic units. Recent developments in the manufacturing environment necessitate the enhancement of cost systems and management accounting to better meet the needs of management in economic units. Management accounting methods, tools, and techniques have become effective instruments that assist and support management in providing the appropriate information for decision-making, thereby reducing costs without compromising product quality. The Theory of Constraints (TOC) is one of these methods or techniques that management in economic units can heavily rely on. Recently, there has been an increased interest in the concept of rationalizing management decisions related to cost reduction due to sustained competition among economic units in terms of price, quality, speed of delivery, and other intense competition methods, as well as the scarcity and limitation of resources. Therefore, the importance of using the Theory of Constraints arises to focus on identifying the obstacles that hinder or impede the improvement of economic unit performance and the cost reductions caused by those constraints, and then working to eliminate them by providing economic units with the necessary information for continuous success and advancement. To achieve this, the researchers divided this study into four sections. The first section addresses the methodological framework and some previous studies, while the second section discusses the theoretical aspect of cost reduction. The third section is dedicated to the practical aspect, and the study concludes with the fourth section, which highlights the main findings and recommendations made by the researchers.

First: Research Methodology

1. Research Problem: Many profit-oriented industrial economic units in Iraq face numerous issues, including the problem of rising production costs. Relying on traditional methods or techniques to reduce costs is often accompanied by significant shortcomings, in addition to the internal and external constraints faced by the management of these economic units that affect the efficiency and effectiveness of resource utilization and their competitive capacity, ultimately impacting profit maximization. This has led to the necessity of employing modern techniques or methods that assist in rationalizing administrative decisions related to production, managing constraints and bottlenecks, and optimizing the use of constrained resources. To express the research problem, we present the following questions that the researchers aim to answer through this study:

- a. Does the application of the Theory of Constraints lead to rationalizing administrative decisions related to cost reduction and, consequently, profit maximization?
- b. Does the use of the Theory of Constraints in industrial economic units lead to a reduction in production costs?
- c. Is there a relationship between the Theory of Constraints and the reduction of production costs?

2. Research Objectives: Based on the research problem and the presented questions, the research aims to study the application of the Theory of Constraints (ToC) in Iraqi industrial economic units. The main objective of the research can be clarified by dividing it into the following sub-objectives:

- a. To apply the Theory of Constraints in Iraqi industrial economic units and demonstrate its role in reducing production costs by identifying constraints and bottlenecks and eliminating them.
- b. To clarify the relationship between the Theory of Constraints and cost reduction by providing relevant and appropriate information to management in industrial economic units to facilitate appropriate decision-making.

3. Importance of the Research: The importance of the research lies in the need for Iraqi industrial economic units to utilize modern techniques or methods in managerial accounting that contribute to rationalizing management decisions related to costs. The research addresses one of the modern techniques in managerial accounting that allows for the proper practical application of cost reduction. Therefore, the importance of the research can be clarified as follows:

- a. Clarifying the role of the Theory of Constraints in providing suitable and relevant information to rationalize management decisions for optimal use of constrained resources in industrial economic units with the aim of improving their performance and reducing their costs
- b. Clarifying the role of cost management techniques (Theory of Constraints) in identifying constraints and bottlenecks in the production process and eliminating them.
- c. Reducing production costs in industrial economic units and subsequently maximizing profits.
- d. The scientific importance of the research, which is considered a significant addition for researchers in the

field of cost management techniques and their role in cost reduction.

4. Research Hypotheses: The research is based on the following fundamental hypotheses- 4

- a. There is a relationship between the Theory of Sustainable Constraints and cost reduction in economic units.
- b. Iraqi industrial economic units have not applied the Theory of Sustainable Constraints to identify and eliminate constraints and bottlenecks in order to reduce associated costs.
- c. The application of the Theory of Sustainable Constraints aids in managing constraints and bottlenecks, which contributes to improving the operational performance of the economic unit with the aim of maximizing its profits, as the research sample economic unit possesses the requirements for applying the Theory of Sustainable Constraints.

5. Research Community and Its Application: The targeting of the industrial sector in Iraq, which includes Iraqi industrial units, has been identified as the community for study, due to its significant importance in the economic development of the country as well as its notable impacts on the environment and human health, resulting from the various industrial waste it generates and its effects on the environment and its diverse components. Therefore, based on the size of this large sector and the multiplicity and complexity of its industrial economic units, the Iraqi Cement State Company has been chosen as the subject of the research

6. Research Boundaries

a. Spatial Boundaries: The spatial boundaries of this research are represented by the General Company for Iraqi Cement/Kufa Cement Plant, located in Al-Braika - Al-Kufa District, Najaf Governorate. The focus on this plant aims to explore or identify the technologies and methods that work to improve and develop performance.

b. Temporal Boundaries: Financial data and reports pertaining to the General Company for Iraqi Cement/Kufa Cement Plant for the years (2022-2021-2020) have been adopted.

Secondly: Previous Studies

1. (Study by Abd Al-Nour and Al-Ajab, 2021): "The Impact of the Integration between the Theory of Constraints and the Value Chain on Reducing Production Costs in Sudanese Industrial Companies," which aimed to demonstrate the effect of the integration between the Theory of Constraints and the Value Chain on reducing production costs in Sudanese industrial economic zones by applying the Theory of Constraints and identifying the main constraints imposed on them and working to eliminate them with the goal of reducing their production costs and using the value chain approach to manage costs by identifying the activities within the value chain, in addition to maintaining the required quality level to achieve a sustainable competitive advantage. The study concluded that the integration of

management accounting techniques and methods (Theory of Constraints and Value Chain) assists the management of economic units in clarifying ways to reduce their production costs and improve their overall performance.

2. (Mohammed and Othman Study, 2022): "The Impact of Applying the Theory of Constraints on Cost Reduction in Manufacturing Companies," which aimed to measure the effect of applying the Theory of Constraints in industrial economic units to reduce their product costs. The study reached a set of conclusions, the most important of which is that the Theory of Constraints helps industrial economic units establish a production schedule, as well as maximize the efficiency of resource utilization in the best possible way, thus contributing to cost reduction for industrial economic units. It also emphasized the importance of using the Theory of Constraints to identify production constraints and work on resolving them.

3. (Soumen Dutta Study, 2023): "The Theory of Constraints: A Framework for Enhancing Efficiency and Promoting Growth," which aimed at the actual use of the Theory of Constraints to improve efficiency and achieve success by identifying constraints and bottlenecks and working to eliminate them. The study concluded with several findings, the most significant of which is that adopting the ideas of the Theory of Constraints helps industrial economic units benefit from their untapped potentials and thrive and grow in the face of the current competitive environment by improving efficiency and reducing production costs to enhance profitability and achieve sustainability

Chapter Two: Theoretical Aspect

1. The Concept and Definition of the Theory of Constraints and Its Development Stages: The Theory of Constraints (TOC) was initially defined as the management of problems that prevent or limit an economic unit from achieving its objectives. However, it was later refined by Goldratt to be applicable in management and cost accounting (Ronen, 2005:1-2). According to Goldratt ^[1], activities within an economic unit resemble a chain, with each chain having a weak link, known as a constraint. Since the strength of the chain depends on the strength of its weakest link, it is essential to strengthen that link, meaning that constraints and obstacles must be removed to improve the entire system (Buyukilmaz & Gurkan, 2009:181). According to the Theory of Constraints, there is always at least one obstacle in any economic unit that prevents or limits management from reaching its goals, and the capacity of the economic unit is constrained ^[2] by the existing limitations in the production process. Therefore, it is necessary to identify and eliminate those constraints to increase production capacity and eliminate associated costs.

The Theory of Constraints also emphasizes that the removal of one constraint leads to another constraint that must also be eliminated. Thus, TOC leads the economic unit to a process of continuous improvement ^[3] (Yuksel, 2011:24-36). Additionally, Horngren (2021) noted that TOC is one of the modern techniques of management accounting that focuses on the importance of managing constraints in a way that increases productivity margins while reducing investments and operating costs and increasing profit margins for the economic unit (Horngren et al., 2021:502-503). It has gone through five stages to reach its current state, with the first stage (1979-1984) being the optimal production technology introduced by Goldratt aimed at increasing the production of an economic unit unable to meet demand. Due to the restrictions imposed on its products, the second phase (1984-1990) was the goal setting phase, which served as a management philosophy aimed at educating managers and employees on how to apply the Theory of Constraints (TOC) through five focusing steps to address and eliminate constraints (Watson et al., 2007: 392). The third phase (1990-1994) involved performance accounting, which is considered an effective approach but requires adoption through a performance measurement system. The goal of this phase was to increase the productive capacity of the economic unit, leading to the development of a performance measurement system based on the application process, referred to as performance accounting, aimed at achieving the maximum possible sales while reducing inventory levels and operating costs, working in tandem with financial performance. In the fourth phase (1994-1997), Goldratt published a new book titled "It's Not Luck," which served as a roadmap for discovering solutions to complex problems known as thinking processes, focusing on root problems and providing alternative solutions (Simsit et al., 2014: 933-936). The fifth and final phase (1997-present) witnessed a new development in the Theory of Constraints called Critical Chain Project Management, aimed at scheduling and controlling various activities within the economic unit (Cox et al., 2005: 43)

2. Sustainable Theory of Constraints (STOC): This is an evolution of the traditional Theory of Constraints, which proposes the existence of natural constraints on the sustainability of economic growth. In other words, there are environmental, economic, and social limits to sustainable economic growth. Therefore, countries, communities, and economic units must take this into account when formulating their economic policies. STOC emphasizes the necessity of preserving the environment and natural resources to ensure the long-term sustainability of economic units by identifying and sustainably removing related constraints, in addition to directing attention towards innovation and technology through investment to improve resource efficiency and reduce waste, pollution, and related

¹ Eliyahu Moshe Goldratt (March 31, 1947 - June 11, 2011) was a business management expert and the creator of the Theory of Constraints, optimal production techniques, critical chain project management, and other tools derived from the Theory of Constraints <https://2u.pw/ShtY8>.

² Entry: Everything that prevents what can be done or controlled <https://2u.pw/OEVTH>

³ Continuous Improvement Process: A compound term consisting of two parts meaning "change for the better." It is an effective means of achieving continuous improvement and a philosophy innovated by Taiichi Ohno to lead industrial economic units and financial institutions, as well as its applicability in all aspects of life, relying on analysis and process <https://2u.pw/UPPG3ag5>

costs. Consequently, STOC includes a set of characteristics that can be clarified as follows:

- a. **Sustainable resource focus:** STOC enhances the sustainable focus of resources and efforts on the most important activities and areas rather than distributing them thinly and unevenly across the entire system, thereby helping to achieve system goals more effectively.
- b. **Sustainable productivity improvement:** The economic unit can sustainably improve its productivity and reduce the time required for this while increasing production capacity by using STOC to identify constraints and bottlenecks that limit this and addressing them sustainably.
- c. **Sustainable and continuous improvement:** STOC works to identify and periodically address constraints, which helps improve the sustainable performance of the entire system over time.
- d. **Cost reduction:** Economic units can improve the quality of their products by overcoming constraints that limit or prevent this, which reflects in the reduction of costs associated with rework or defective production.
- e. **Achieving sustainable competitive advantage:** Once the economic unit maximizes the benefit from its resources and overcomes constraints, it can achieve a sustainable competitive advantage by offering high-quality products at lower costs.
- f. **Achieving goals:** The economic unit can achieve its goals more efficiently after overcoming constraints, achieving a sustainable competitive advantage, reducing production costs, and attaining sustainable performance.

Steps for Implementing STOC in Industrial Economic Units

Soumen outlines five steps for implementing the Theory of Constraints in economic units that suffer from constraints or limitations preventing them from achieving the desired performance. The researcher can adopt these steps for the sustainable application of the Theory of Constraints as follows (Soumen, 2023:36):

- a. **Identify the Constraint:** This involves identifying the process with insufficient capacity to meet demand by analyzing resource flow or gathering performance information. This may include the use of specific tools such as flowcharts ^[4] or process maps ^[5], among others.

⁴ data flow diagram is a graphical representation of the flow of data between various processes in business and commercial activities. It is also a graphical technique that visualizes how information flows applied in the transfer of data from inputs to outputs. It provides a simple and intuitive way to describe business processes and their flow within the various activities of the economic unit <https://2u.pw/oh79X>

⁵ Operational Map: A versatile tool that helps clarify the workflow of various business activities to improve

For example, in the procurement department, a supplier's capacity can become a bottleneck if one of the suppliers struggles to meet the varying demands of different customers (economic units), resulting in delays in the delivery of production items.

- b. **Sustainable Exploitation of the Constraint:** Once the constraint is identified in the first step, the second step is the sustainable exploitation of the constraint by maximizing every part of the constraint component without committing to potentially costly changes and/or upgrades. Adequate effort should be made to ensure the constrained process or supplier is fully utilized. In the previous example, the procurement department of the economic unit must have a clear understanding of the supplier's capacity or delivery schedules.
- c. **Subjecting Everything Else to Constraints:** The next step in implementing the STOC is to subject all other activities within the economic unit of the supplier or the constrained process. More specifically, the management of the economic unit must adjust the rest of the system to enable the constraint to operate at maximum capacity. In the previous example, the entire production schedule must align with the supplier's capacity.
- d. **Elevating the Constraint:** The fourth step in implementing the STOC is to make the necessary decisions and steps to remove the constraint. If the economic unit has reached the fourth step, it indicates that the previous steps have been insufficient in eliminating the constraint or have been unable to render that process unconstrained. This may involve making significant changes to the current system of the economic unit, such as reorganization or capital improvements, among others.
- e. **Returning to the First Step:** The final step in implementing the STOC is to return to identify the new constraint. Caution is advised against stagnation after breaking the constraint; rather, the economic unit should reorganize the steps anew to seek the new constraint that limits the performance of the system.

4. Concept of Cost Reduction and Its Definition

Recent developments in the business environment have led to increased competition among economic units in the markets, prompting many economic units to review their operations and activities to become more efficient and effective, and to seek opportunities for cost reduction in order to achieve appropriate financial results and satisfy customers and shareholders. Consequently, the idea of cost reduction has significantly captured the accounting thought in economic units to reach more accurate techniques, methods, or methodologies that contribute to reducing

efficiency, as it allows for the presentation of explanations that facilitate the exchange of ideas to enhance processes within the economic unit's activities <https://miro.com/ar/process-mapping/what-is-process-mapping/>

production costs (Spee & Douw, 2003:32). Thus, the concept of cost reduction is defined as a planning approach aimed at improving efficiency in the economic unit through the optimal use of cost elements and increasing production or speeding up the completion of production processes, which positively reflects on reducing the cost per unit produced without affecting its quality (Ibrahim, 2021:45). It is defined by Al-Jiyoushi (2019) as the process of achieving savings in the costs of various activities of the economic unit by reducing the effort and time required to complete them or by excluding some overlapping activities in the production process, with the condition that the exclusion does not affect the quality and characteristics of the product (Al-Jiyoushi, 2019:60). Therefore, the philosophy of cost reduction is considered a primary goal for economic units seeking to maintain their sustainable competitive advantage in the market over the long term. There are many motivations and reasons that drive economic units to employ techniques, methods, or strategies aimed at reducing the costs of their products, and some of these reasons or motivations can be illustrated as follows (Steven, 2010:4-7):

A. Addressing the Problem of Price Decline: There is an urgent need for a cost reduction process aimed at addressing the issue of declining profits due to the price decreases faced by the economic unit's products. This necessitates a reduction in production costs to keep pace with such price changes. The cost reduction process yields numerous benefits for the economic unit, which include achieving savings in profits and improving the relationship between employees and management. Cost reduction leads to more funds, which helps in caring for the health and welfare of employees, as well as providing goods and services to customers at lower prices and increasing demand for them. Additionally, it contributes to continuous improvement and long-term benefits.

B. The Feasibility and Simplicity of the Cost Reduction Philosophy Compared to Revenue Increase: In fact, the process of reducing production costs is one of the main methods for increasing expected profit in the short term. The economic unit can achieve additional profits without the need to increase sales by reducing operating costs, which may include efforts to improve production processes, enhance resource utilization efficiency, or even reduce administrative costs. It is also a key driver of long-term growth, as the cost reduction process can contribute to enhancing profitability and sustainability while providing products and services that meet the diverse needs of customers at lower prices. The process of reducing production costs differs from that of increasing revenues; the latter may involve specific strategies such as expanding market share, developing new products, or improving market strategies, while the cost reduction process typically addresses the internal operations of the economic unit and how to enhance its efficiency and reduce direct costs.

C. Increasing Costs: Refers to the gradual increase in total costs over time, which represents an ongoing issue for the economic entity, as it reduces its capacity to operate and negatively affects its profitability. The primary challenge with these costs is that they do not appear suddenly but rather develop slowly over time, making it difficult for management to identify them in the short term. Due to this gradual development, management may not be motivated to

take immediate action to address these costs. However, when these costs become urgent to the extent that they threaten the financial sustainability of the economic unit, it becomes essential to take effective measures to eliminate them. Typically, the process of dealing with such costs requires additional effort to restore previous profit levels. Therefore, it is crucial to employ an effective management philosophy or technique within the economic unit to reduce these costs. Strategies for eliminating these increasing costs include analyzing and improving internal processes, as well as creative thinking on how to reduce these costs without impacting product quality or customer service.

5. The Importance of Reducing Production Costs in the Economic Unit

Reducing production costs is considered one of the management techniques employed by the economic unit through enhancing productive efficiency by optimally utilizing cost elements and expediting its processes without compromising product quality. The significance of the cost reduction process is derived from the relationship between cost, profit volume, and selling price. Additionally, the cost reduction process supports the competitive position of the economic unit in the market by offering products at competitive prices compared to those of other economic units, as well as being prudent and economical in the use of production elements, as this is the proper avenue for reducing costs and increasing productive efficiency (Al-Noor & Al-Ajab, 191:2021).

The Role of STOC in Reducing Production Costs 6 -

The Theory of Constraints (TOC) is a framework aimed at improving the management of the economic unit and increasing its productive efficiency by identifying obstacles and constraints that prevent or hinder the economic unit from achieving its goals and eliminating them. Therefore, the role of the Theory of Constraints in reducing production costs is realized through the following:

- a. **Identification of Constraints:** STOC focuses on identifying processes or factors that limit the economic unit's capacity and cause an unjustified increase in production costs, whether these constraints are technical, operational, or other types of limitations.
- b. **Resource Utilization Improvement:** By identifying constraints and concentrating efforts on improving the performance of these constraints, the economic unit can enhance its resource utilization and increase efficiency without the need to raise costs.
- c. **Continuous Improvement:** Identifying waste and loss in activities, time, and resources that do not add any value to the product, which are accompanied by an increase in production costs, and working to eliminate and sustainably remove them.
- d. **Focus of Efforts:** After identifying the main constraints in the production processes of the economic unit, it can direct its efforts and resources towards overcoming these obstacles instead of dissipating effort in areas that do not lead to the desired performance improvement.

- e. **Reduction of Storage Costs:** Implementing inventory management techniques or reducing inventory levels to the ratios that allow the production process to proceed without the unjustified increase in raw material stock, which is considered the main reason for the rise in production costs.
- f. **Reduction of Waste and Squandering:** The sustainable theory of constraints can be used to analyze production processes within the economic unit and identify activities that cause waste and squandering, and then improve those processes or activities to reduce the unnecessary costs associated with them.
- g. **Improvement of Product Quality:** By focusing efforts on improving the quality of products and services, the economic unit can avoid costs associated with rework, warranty, and maintenance.
- h. **Supply Chain Improvement:** By using STOC, supply chain management can be enhanced to achieve greater efficiency in resource distribution and cost reduction related to inventory and transportation.

7. Elements of Cost Reduction in Production Using STOC

There are numerous elements that can undergo cost reduction processes and improve production efficiency, and they are not limited. Any element or department of the economic unit or stage of its production may be considered a component of production cost reduction in the economic unit, which can be clarified as follows:

- a. **Raw Materials:** Using lower-cost or alternative raw materials or improving purchasing processes to obtain better prices.
- b. **Workers:** Increasing worker productivity through training and development and better organization of work to reduce time waste and increase output.
- c. **Technology and Equipment:** Utilizing modern technology and more efficient equipment to enhance productivity and reduce production costs.
- d. **Production Processes:** Improving the production process chain and eliminating unnecessary processes.
- e. **Storage and Delivery:** Enhancing storage and delivery processes to reduce costs arising from delays and losses.
- f. **Marketing and Sales:** Improving marketing strategies and increasing the efficiency of sales processes, including transportation, packaging, installation, and maintenance costs.

From the above, it is evident that the Theory of Constraints plays an active role in reducing production costs in industrial economic units. Therefore, the next section of this research will highlight this practically by illustrating the role of the Theory of Constraints in reducing the production costs of the economic unit under study, which has been chosen by the researchers because it is one of the leading industrial economic units in Iraq in terms of production and high product quality.

Section Three Practical Aspect

1. Definition of the Nature of the Economic Unit: The Kufa Cement Plant, located in Najaf Governorate, Al-Kufa District - Al-Braika, is considered one of the important facilities affiliated with the Iraqi Cement Company, one of the formations of the Ministry of Industry and Minerals. This plant was established in 1977 with the aim of producing cement, at a cost of approximately IQD 63,233,500. The plant was designed and implemented by the Danish company F.L.S. It consists of four production lines with a designed capacity of 1,781,000 tons of cement annually, adopting the wet method in cement manufacturing. The designed capacity of the clinker kilns is 1,728,000 tons annually. The products of the plant are characterized by full compliance with Iraqi specifications No. 5 of 1984 and meet all requirements of the Ministry of Industry and Minerals in Iraq.

The products of Al-Kufa Cement Plant include 2 -

A. **Ordinary Portland Cement:** The plant began producing this type of cement in accordance with Iraqi Standard Specification No. 5 of 1984. This cement is characterized by its high quality, which led the plant to obtain the ISO 9001-2008 quality certification. However, production ceased in 2004 due to the entry of foreign salt-resistant cement of better quality and lower cost into the local market. Consequently, the plant decided to shift to the production of resistant cement instead.

B. **Sulfate-Resistant Portland Cement:** This type is produced in accordance with Iraqi Standard Specification No. 5 of 1984. This cement enjoys high quality that qualifies it to compete in the local market and to contend with similar local or imported products. This cement has also obtained the ISO 9001-2008 quality certification and is available in the local market either as bulk cement or packaged in bags. The following Table (1) shows the planned and actual production quantities, as well as the design capacity of cement and clinker over the past four years (2020-2021-2022-2023)

Table 1: Design Capacity and Actual and Planned Production of Al-Kufa Cement Plant between (2020-2023) in tons

Actual Production Percentage (%)		Actual Production	Planned Production	Design Capacity	Year	Type of Production
Planned Production	Design Capacity					
82%	38%	649754	795400	1728000	2020	Clinker Material
80%	37%	632506	795400	1728000	2021	
82%	38%	650378	795400	1728000	2022	
92%	42%	733038	795400	1728000	2023	
91%	%42	744723	820000	1781000	2020	Resistant Cement
80%	37%	657310	820000	1781000	2021	
89%	41%	729310	820000	1781000	2022	
101%	49%	834620	820000	1781000	2023	

Source: Table prepared by the researchers based on the Production and Planning Department in the plant.

Table 2: List of Fixed and Variable Costs for Al-Kufa Cement Plant

Iraqi Cement Company / Al-Kufa Cement Plant									
Cost Based on Actual Labor				Cost Based on Actual Expenses			December 2022 Accumulated		
Cost per Ton of Cement	Cement Grinding Cost	Clinker Cost	Discount Rate	Cost per Ton of Cement	Cement Grinding Cost	Clinker Cost	Amount %100	Account Name	Account Number
24772	2233	22539	40%	41287	3722	37565	27146236014	Salaries and Wages	31
19333	867	18466	0%	19333	867	18466	12641906392	Raw Materials and Commodities	321
13305	1199	12105	0%	13305	1199	12105	8747699090	Fuel and Oils	322
9267	835	8432	0%	9267	835	8432	6093009395	Spare Parts	323
--	--	--	0%	--	--	--	4097581226	Packaging Materials	324
887	80	807	0%	887	80	807	583172383	Miscellaneous	325
182	16	166	0%	182	16	166	119913895	Employee Equipment	326
5916	533	5383	0%	5916	533	5383	3889772573	Water and Electricity	327
2736	247	2489	0%	2736	247	2489	1798621591	Maintenance Services	331
2	0	1	0%	2	0	1	1000000	Research and Consulting Services	332
35	3	32	0%	35	3	32	22775000	Advertising, Printing, and Hospitality	333
1924	173	1750	0%	1924	173	1750	1264857895	Transport, Travel, and Communications	334
1805	163	1642	0%	1805	163	1642	1186797372	Lease of Fixed Assets	335
158	14	143	0%	158	14	143	103663122	Miscellaneous Service Expenses	336
--	--	--	0%	--	--	--	---	Interest and Land Rentals	36
10248	924	9324	0%	10248	924	9324	6737745744	Depreciation	37
399	36	363	0%	399	36	363	262619773	Transfer Expenses	38
131	12	119	0%	131	12	119	86113816	Other Expenses	39
91098	7337	83762	Dinar	107613	8825	98788	Total Expenses	Total Expenses	
		107613	Dinar	54365	4901	49464	35744925260	Fixed Costs Excluding Administrative	
			Dinar	53248	3924	49324	39038560476	Variable Costs Excluding Administrative	
							1003424	Break-even Point	

Source: Table prepared by the researchers based on the Cost Division report of Al-Kufa Cement Factory.

The table above indicates an increase in production costs for the Al-Kufa Cement Plant, which reflects in the heightened cost of producing one ton, amounting to IQD 91,098. Therefore, the application of the Theory of Constraints (TOC) is considered an important management approach to identify the constraints behind the rise in these costs and to work towards sustainably resolving them to achieve cost savings.

3. Application of TOC to Identify Constraints and Bottlenecks and Reduce Production Costs at Al-Kufa Cement Plant

It is evident from the above that the Al-Kufa Cement Plant faces several challenges, the most prominent being weak production capacity and high production costs, which are the main reasons behind other issues, such as declining revenues and the recurring losses incurred by the plant in recent years. Therefore, through the application of TOC, the key constraints of low production capacity and the associated high costs can be identified and sustainably eliminated, achieving the required cost savings and reflecting this in the reduced cost per ton, as follows:

a. Equipment and Capacity Constraints: Through the researcher's field visit to the Al-Kufa Cement Plant and the study and analysis of the performance results achieved at the plant, along with obtaining the cost report for producing one ton for the year 2022, as illustrated in the table above, it became clear that the plant faces a shortage of modern machinery and mills with high production capacity. Instead, it relies on old machinery, mills, and crushers, which require frequent maintenance stoppages and incur high costs, in addition to the significant reduction in the quantities of clinker produced, which is the main material used in cement production, as well as in the final product of the plant, namely, resistant cement.

b. Market Constraints: The plant faces competitive challenges in the local market due to its use of local clinker, which is characterized by very high costs compared to the imported clinker used by other plants in their manufacturing processes according to the blending method. In addition, the increase in the number of employees and high monthly wages and bonuses has significantly raised production costs, thereby reducing its ability to compete sustainably in the market.

c. Resource Constraints and Their Harmful Environmental Impacts: The plant relies entirely on local production inputs, making the age of the machinery and mills a significant challenge to the process of reducing production costs, as they leave behind a lot of harmful environmental waste. Furthermore, the reliance on the wet production method requires large quantities of water, which incurs very high costs compared to other methods, impacting sustainability in its production operations to preserve non-renewable natural resources and to ensure the health and safety of workers from harmful effects.

4. Lifting constraints through the application of STOC to reduce production costs at the Kufa Cement Plant

a. Lifting equipment and capacity constraints: Replacing the kilns used in the production of clinker, which were the main reason for the low production capacity and high production costs, will yield positive results for the plant by increasing the quantities produced and transitioning them to the subsequent phase. Additionally, reliance on natural gas will significantly contribute to reducing production costs by lowering the fuel cost involved in the production of one ton. One ton of cement requires 83 liters of heavy fuel oil, with a cost of 100 ^[6] dinars per liter and an additional 5 dinars as transportation costs, resulting in a total cost of 105 dinars per liter for heavy fuel. Therefore, the fuel cost required to complete the production process of one ton of clinker is:

$$105 \text{ Dinars} \times 83 \text{ Liters} = 8,715 \text{ Dinars per ton}$$

Therefore, the fuel cost required for the production in 2022 of 650,378 tons of clinker is:

$$8,715 \text{ Dinars} \times 650,378 \text{ tons of clinker} = 5,668,044,270 \text{ Dinars}$$

However, in the case of the plant using natural gas instead of heavy oil, the quantity required to produce one ton of clinker will be (0.08) cubic meters of gas, which means 80 liters of gas at a rate of 100 dinars per liter. Therefore, the fuel cost required to produce one ton of clinker is:

$$100 \text{ Dinar per liter} \times 80 \text{ liters per ton} = 8,300 \text{ Dinar per ton}$$

Therefore, the fuel cost required for the production of 650,378 tons of clinker is:
 $8300 \text{ Dinar/ton} \times 650,378 = 5,398,137,400 \text{ Dinar}$

It is evident that the use of natural gas at the Kufa Cement Plant instead of black oil will lead to cost savings, as shown in the following table:

Table 3: Cost comparison of fuel types used.

Difference	Cost of Production Using Gas	Cost of Production Using Heavy Oil	Unit of Measurement	Details
269,906,870	5,398,137,400	5,668,044,270	Dinar	Cost of Production

Source: Prepared by the researchers

The table above confirms that the use of natural gas in the Kufa Cement Plant will achieve cost savings of IQD 269,906,870, thereby contributing to a reduction in total production costs and the realization of profits.

b. Lifting market restrictions: The second and significant constraint in the process of reducing production costs is the import of clinker, as practiced in other competing plants that operate on a blending basis. This has very important effects on the process of reducing production costs and achieving profits, as it is characterized by a very low price compared to the local product (clinker). The price of one ton of imported clinker has reached USD 35 for purchase and IQD 20,000 for transportation within Iraq per ton. Therefore, through the exchange rate of the Iraqi dinar ^[7] against the dollar, the cost of one ton arriving at the plant will be determined in Iraqi dinars and compared to the cost of producing it locally as follows:

Exchange rate: 1,320 dinars per 1 USD
 Purchase price: USD 35
 Cost of purchasing one ton in Iraqi dinars = USD 35 × 1,320 dinars = 46,200 Iraqi dinars
 Transportation costs of 20,000 dinars are added, making the total purchase cost = 66,200 Iraqi dinars

Therefore, the process of purchasing or importing clinker and blending it with local clinker will contribute to reducing production costs, in addition to the absence of environmental impacts associated with the production of this material from combustion, grinding, and other processes. The following table illustrates the savings achieved in production costs from the blending process between local and imported clinker as follows:

Table 4: Savings from production cost achieved through the blending of locally produced and imported clinker

Difference	Cost of imported clinker used in the production process	Cost of locally sourced clinker used in the production process	Unit of Measurement	Details
6,285,281,740	23,692,384,200	29,977,665,940	Dinar	Cost Savings

Source: Prepared by the researchers based on laboratory data.

The table above indicates that the use of a blending process between locally sourced and imported clinker for the quantity allocated for production during the year 2022, which is estimated at 715,782 tons according to the production department reports, would result in achieving cost savings of 6,285,281,740 Iraqi Dinars if a blending ratio of 50% were adopted.

c. Resource Deconstraining and Its Impacts: Environmental preservation has become a public duty, and currently, industrial units are considered a major source of pollution due to the pollutants and harmful gases they emit. Therefore, immediate measures must be taken to mitigate this environmental impact and to employ technologies and practices that reduce the resulting damages and conserve non-renewable resources. In the case of water, the plant consumes very large amounts, as it relies on the wet method in cement production, which is accompanied by a significant increase in production costs. Thus, the use of alternative methods is considered a suitable solution for Al-Kufa Cement Plant to avoid many costs. The following table illustrates the cost savings achieved by using the semi-dry method as follows:

⁶ A price subsidized by the Iraqi Ministry of Oil for industrial plants such as brick factories and cement factories

⁷ The exchange rate is 1,320 dinars per 1 dollar as it is subsidized for traders by the government according to the announced rate.

Table 5: The difference between the quantity and costs of water consumption in the production stages when using the semi-dry method

Cost in dinars	Cost per cubic meter	Quantity/m ³	Percentage	Details
95593317	100.218	953853.77	50%	Work according to the wet method
24854264	100.218	248002	13%	Work according to the semi-dry method

Source: Prepared by the researchers.

It is evident from the table above that the use of the semi-dry method will reduce the amount of water consumed in the production process by 705,851.77 m³, resulting in cost savings of 70,739,053 Dinars, in addition to adhering to sustainability standards to preserve natural resources from waste.

Furthermore, the issue is not limited to water alone but also includes the gases emitted from the plant. The outdated technologies used in production processes, the aging of production lines.

and the lack of adequate and efficient maintenance procedures, along with insufficient control measures, are significant sources of air pollution from emitted gases. These emissions have substantial impacts on the health and safety of workers and the surrounding environment, as the plant is located near residential areas. The following table shows the total greenhouse gas emissions amounting to 2,750 metric tons, while the acceptable limit within sustainability standards is 1,500 metric tons, as illustrated in the table below:

Table 6: Details of Emissions from the Plant

Type of Deviation	Deviation	Global Accepted Standards Percentages and Quantities	2022 Emissions	Unit of Measurement	Details
Unfavorable	(8%)	76%	84%	Percentage	CO2 Gas
Unfavorable	(4%)	1%	5%	Percentage	CO2 Gas
Unfavorable	(10%)	1%	11%	Percentage	Other Gases
Unfavorable	(1250)	1500	2750	Metric Ton	Total Pollutant Gas Emissions

Source: Prepared by the researchers based on plant data.

The table above indicates that the plant has exceeded the legally acceptable limit or the accepted benchmark by 1,250 metric tons of pollutants. The data also showed that the main gases emitted include carbon oxides, nitrogen oxides, sulfur oxides, and hydrocarbons, which are considered some of the most significant air pollutants. Their health effects vary based on their type and duration of exposure. Based on the above, the economic unit under investigation will be required to pay financial penalties in accordance with the fines imposed by the World Bank Group^[8], which amount to USD 100 for each metric ton of polluting gases, equivalent to approximately IQD 145,000^[9]. Therefore, the penalty imposed on the plant can be calculated as follows:

Total cost of fines imposed for gas emissions = 1,250 metric tons × 145,000 Iraqi Dinar per metric ton = 181,250,000 Iraqi Dinar

From the above, it is evident that if the plant adheres to the specified standard ratio, it will save the imposed fine amounting to (181,250,000) Iraqi Dinars.

Therefore, the application of the Theory of Sustainable Constraints at the Kufa Cement Plant is considered a suitable solution to challenge and eliminate the main constraints in increasing production costs through the implementation of the previous steps and working accordingly, which leads to achieving cost savings as well as compliance with environmental and social sustainability standards. The following table illustrates the cost savings achieved from the application of the Theory of Sustainable Constraints as follows:

Table 7: Savings Achieved in Production Costs from the Application of STOC

Difference	Production Costs After STOC Implementation	Production Costs Before STOC Implementation	Details
269,906,870	5,398,137,400	5,668,044,270	Cost Savings from Fuel Usage
6,285,281,740	23,692,384,200	29,977,665,940	Cost Savings from Blending Process
70,739,053	24,854,264	95,593,317	Cost Savings from Semi-Dry Method
181,250,000	217,500,000	398,750,000	Cost Savings from Compliance with Pollutant Gas Emission Standards
6,807,177,663	29,332,875,864	36,140,053,527	Total Production Cost Savings

Source: Prepared by the researchers.

The table above indicates that the use of the Theory of Sustainable Constraints will achieve significant savings in production costs, positively reflecting on the reduction of the cost of producing a single unit. Therefore, the application of the Theory of Sustainable Constraints will reduce total production costs by an amount of (6,807,177,663), equivalent to (8,292^[10]) dinars per ton.

****Chapter Four****

****Conclusions and Recommendations****

⁸ 2018 The World Bank Group
<https://data.worldbank.org/indicator/EN.ATM.CO2E.PP.GD.KD>

⁹ According to the exchange rate of the US dollar against the Iraqi dinar as of July 14, 2024.

¹⁰ $0.0910 = \frac{6,807,177,663}{74,783,485,736} \times 91098$

First: Conclusions

1. The application of the Theory of Constraints (ToC) has an impact on inventory scheduling and reduces the time required for the production process, as well as improves resource utilization efficiency, which means a reduction in associated costs.
2. The application of the sustainable Theory of Constraints contributes to finding a sustainable solution and performance for economic units that suffer from constraints and limitations, meaning a reduction in the costs imposed on them due to their harmful environmental and social impacts, which in turn reduces production costs and consequently lowers the cost per unit.
3. Implementing the sustainable Theory of Constraints in economic units will positively reflect on lower prices and higher quality levels of their products by identifying and removing the constraints that hinder this.
4. The results of applying the sustainable Theory of Constraints indicate a close relationship between the sustainable Theory of Constraints and the reduction of production costs through its effective role in lowering those costs.
5. Al-Kufa Cement Factory suffers from weak production capacity, which is attributed to its reliance on outdated machines and mills, and the lack of any updates to the production lines, which are considered constraints and limitations that hinder the factory from achieving the desired performance due to low production capacity, in addition to the environmental impacts it generates, which significantly increase production costs.

Second: Recommendations

1. It is essential to utilize the sustainable Theory of Constraints in production economic units to identify the constraints imposed on them and work to eliminate them in order to increase production capacity and reduce associated costs.
2. Conduct benchmarking comparisons before and after the application of the Theory of Sustainable Constraints to determine the extent of cost reductions achieved through the implementation of the Theory of Sustainable Constraints, as well as to identify and eliminate constraints and limitations, in addition to uncovering new constraints or limitations and working to eliminate them as well.
3. It is essential for the management of economic units and their employees to recognize the importance of applying the Theory of Sustainable Constraints, as it is a management philosophy that enables its users to identify the most significant constraints affecting all areas of sustainable performance.
4. Attention should be paid to non-renewable resources, in addition to reducing costs that do not add any value to the product by identifying their causes and working to eliminate them.

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