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Measuring the possibility of smart production application for sustainable production performance

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ABSTRACT

This paper aims to explore the extent to which the Iraqi industrial environment is keeping pace with technological progress. It also attempts to show the role of smart production in environmental sustainability. Using the case study methodology, this paper examines the possibility of applying smart production techniques at an Iraqi factory, Ezz Factory / General Company for electric and Electronics Industries. In addition, this work checks the technical, economic, social, and environmental effects by measuring the gap between the standard conditions as determined by the checklist developed for this purpose and the actual real application of all the smart production dimensions in the factory. Previous works used interviews with many managers and technicians through their field visits to gather information and to check many documents. The assessments showed a gap of 50%. Based on the result, the researchers reached several conclusions, the most important of which is that the factory is interested in developing and extending the environmentally friendly production of solar panels. Another important conclusion is the acceptable level of sustainable production performances without a smart production line.

Keywords: Smart Production, Intelligent Manufacturing, Effects of Smart Production, Environmental Sustainability

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1. Introduction

Smart production depends on high technology in its basic operations is a highly flexible production line. It reduces energy waste and rationalizes the use of resources in all the involved elements. This represents a modern and sustainable production method with its effects (technical, economic, social, and environmental), and factories that depend on production. The companies can satisfy their customers' changing demands with more flexibility. To keep pace with the market requirements, the role of smart production and its importance in sustaining productive performance has emerged, so researchers have adopted a case study approach by applying a checklist on the Ezz Factory which is a Public Company of Electrical and Electronic Industries that depend in some of its lines on making environmentally friendly products depending on their actual capabilities available to them.

2. Research methodology

2.1. Research significance

This work is significant because it conducts the following:

1. Exploring the effects (technical, economic, social, and environmental) of smart production would enhance the competitive position of the factory and consolidate its sustainable performance.
2. The factory can improve its production system and sustainable smart production performance.
3. This work makes it possible to measure the gap between the actual and required performance according to a smart and sustainable production system to identify its weaknesses and improve it.

2.2. Research objectives

This work aims at the following:

1. Showing whether Al-Ezz factory products and production plans are smart and their performance is sustainable.
2. Measuring the impact of smart production on sustainable performance at the factory subject of the study.
3. Determining the effects (technical, social, economic, and environmental) of smart production on achieving sustainable performance in the factory.
4. Measuring the gap between what is achieved in the factory and what is planned for environmental sustainability through smart production to enhance the strengths it possesses and to address its weaknesses.

2.3. Research style and limitations

In this paper, we will follow the case study methodology and a checklist will be developed concerning different resources [1, 2] to carry out the research. We use the Likert rating scale with five points: fully applied 4, partially applied 3, Somewhat applied 2, poorly applied 1, not applied 0. Then several statistical measures will be used in analyzing data such as frequency distribution, percentage, arithmetic mean, and hypothetical average rate to determine the level of availability of each statement in the checklist. These measures also help to identify the gap and determine the level of an answer for each point. The research population is Al-Ezz Factory which is part of the Public Company of Electrical and Electronic Industries associated with the Ministry of Industry and Minerals. This factory produces mainly solar panels.

3. Theoretical framework

3.1. Smart production concept

Intelligent production is one of the recently introduced concepts during the fourth industrial revolution. This type of highly automated production system focuses, as goals- keeping pace with the constant technological change, satisfying customers' needs through a computerized manufacturing environment. It also ensures flexibility and high production efficiency. In addition, it integrates various activities and information technology to achieve effective communications between the customer and the producer, and between the producer and the supplies [3]. Besides, intelligent production encourages the use of modern flexible tools that make production operations more effective [4]. Smart production is considered a new level of high automation that links production processes with technologies and offers more effective tight controls, and extensive uses of information to take the required correct decisions.

3.2. Smart production advantages

Smart production has many advantages which can be summarized as follows:

1- This production provides organizations with integrated production systems that meet the customers' needs with high flexibility in the production volume. It also integrates human creativity with automation [5].
2- It enhances the organization's competitiveness in meeting the market requirements more flexibly [6].
3- Intelligent production systems allow the organization to take advantage of the dynamic solutions to unexpected events in the organizational performance [7].
4- Information analysis technology and highly sensitive sensors in the smart production system components reduce both turbulence and time consumption to the lowest possible level [8].

3.3. Smart production levels

There are three possible levels available to the organization when working according to smart production technology [9]:

• Operations Level: It is the adaptation to technological and management systems to a new more advanced level where tools are more effective in enhancing the value of activities creating product or service creation.
• Organizational Level: It is an important innovation that changes the organization's dynamics. It could be a kind of participation through the organizational structures that lead to value-adding and creation which require excellent information management and experienced team works.

• Customers Level: This level is designing smart productions in accordance with the organization's intellectual available capital, its full market dynamics, and the organizational strategic thinking that fits its movement following the technological cycles.

3.4. Smart production importance for sustainability

Building sustainable performance in smart production operations has many technical, economic, social, and environmental impacts on different aspects of the production and human resources [10]:

3.4.1. Technical implications of smart production systems

The smart production system aims to deal with multiple types of products simultaneously. In addition, it coordinates the relationship between machines, information systems, products, and human resources through a high-speed network system. The IT division will require skilled people to design, develop and operate network software and its maintenance [11]. The mentioned modern technological systems that most organizations seek to use in advanced and complex manufacturing operations are an important factor in the development of most of the industrial sectors around the world [12]. The same applies to providing fast products and services that are compatible with the customers' needs, introducing innovations and technical modernity in manufacturing operations reducing maintenance time. This makes production flexible and quicker. Smart production is based on knowledge and skills that seek the most appropriate technological solutions to help the organization achieve its goals related to sustainability. The other most important principle which depends on the in-depth analysis of data is the energy planning and tracking of data in smart production. This tracking depends on the in-depth analysis of data generated and gathered from the movement of machinery and the process of decision-making consistent with the state of the machine. It takes into account the interest of the organization in accumulating the experience and knowledge of workers who control and implement this decision [13].

3.4.2. Economic effects of smart production systems

Improving product quality increases the speed of production, and the instant responsiveness to the meeting of customers' requirements through smart products that will contribute significantly to the profitability increase and the competitiveness improvement of the organization (Kang et al, 2016: 118). Also, costs, in general, will be reduced as the labor number damage and wasted energy are reduced. All this will be reflected in an economic term for the organization [14]. The availability of an intelligent production environment will help workers to adapt to smart machines in a way that allows the management to work according to flexible foundations that lead to the philosophy of entrepreneurial work within the scope of operations of the smart production line [15]. The smart production line is offering several options to the company, all of which are based on how company management is running the production line. Those alternatives include high speed, change of product, change in raw materials and their characteristics to be used in the same production line. All this will contribute to increasing the organization's production flexibility in dealing with suppliers, customers, and competitors [16].

3.4.3. Social effects of smart production systems

Smart production depends on few workers and routine tasks because physical systems can communicate with each other through IT applications. Thus communication is from machine to machine. The main element needed in a smart manufacturing environment is the management's ability to deal with unplanned and sudden events in a systematic way. That helps to keep the work mix and production method within its normal specifications without affecting the machines or workers. In addition, the organization's ability to quickly exchange information and transparency in dealing with crises and effective communication between management and staff are vital factors to include the proposed changes in the performance improvement process [17]. However, humans will remain an important role in planning and controlling functions [18]. The social effects require continuous empowerment and vocational training in companies that contain training courses on smart machines in line with the concern of the sustainable and green environment.

3.4.4. Environmental impacts of smart production systems

Introducing smart production in manufacturing products will minimize wastes and consumption of energy. It creates a balance between supply and demand. Logistics in this sort of manufacturing is based on the pull principle, which means demanding raw materials and semi-finished products upon request. The orders are released automatically from suppliers, as needed. Therefore, in times of slow demand, fewer materials or parts are required. Management in industrial companies must protect the natural environment working on the reduction of pollution, respecting the environmental legislation that imposes rules regarding the use of natural resources, clean production, distribution, consumption, and disposal of materials. Smart production requires a careful strategy to complete manufacturing operations in an environmentally friendly manner with the minimum level of risks, maximum protection of resources, and use of alternative materials. The automation and the introduction of new technology must be accompanied by a high level of awareness of respecting and keeping the natural environment free of pollution. The philosophy of smart production in its core essences calls for eco-controlling along the production line and not just in isolated stations or operations. Strengthening the connections among producers, consumers, and suppliers is another fundamental aspect of this type of smart production [19]. Finally, organizations must work hard to replace the environmentally unfriendly with other more friendly products produced through clean operations. The new products must be compatible with environmental legislation. Also, reducing or eliminating emissions associated with production is another harmful element to humans and the natural environment. This reduction must be an immediate goal that must be achieved by smart production [2].

3.5. The checklist

Relying on the case study methodology, a checklist was developed [2] to carry out the research. This checklist uses the Likert five points rating scale that includes fully applied 4, Partially applied 3, somewhat applied 2, poorly applied 1, not applied 0. Also, frequency distribution, percentage, arithmetic mean and the hypothetical mean rate is used to determine the level of availability of each statement in the checklist and to measure the gap between the actual application and the standards. The following are the results reached after completing the checklist and calculating the mentioned statistical indicators:

Table 1. Technical effects

First Dimension: Technical Effect		Scale				
N0	The company has :	Totally Applied	Partially Applied	Somewhat applied	Poorly Applied	Not Applied
1	Training programs to develop the creative capabilities of workers in smart production techniques			x		
2	High automation for many production and inventory stations		x			
3	An Automated production control system for all the smart manufacturing system operations.			x		
4	Research experts with an outstanding reputation in information technology and automation.		X			
5	Flexible production systems that can produce a high variety of products that satisfy customer's needs.				X	
	Weight	4	3	2	1	0
	Frequency	0	2	2	1	0
	Score	0	6	4	1	0
	Average			2.2		
	Percentage			55%		
	Hypothetical Average			0.11		
	Gap			45%		

Table 2. Economic Effects

Second Dimension: Economic Effect		Scale				
N0	The company has :	Totally Applied	Partially Applied	Somewhat applied	Poorly Applied	Not Applied
1	Flexibility in using alternative materials and the ability to produce products with different specifications.				x	
2	Detailed and flexible programs that can satisfy the increased demand.		x			

Second Dimension: Economic Effect		Scale				
N0	The company has :	Totally Applied	Partially Applied	Somewhat applied	Poorly Applied	Not Applied
3	The ability to fill the gap and get used to the market opportunities when it happens.			x		
4	Flexibility in handling, rotating, and scheduling the workload.		x			
5	The ability to reduce waste and utilize the productive capacity effectively.				x	
	Weight	4	3	2	1	0
	Frequency	0	2	1	2	0
	Score	0	6	2	2	0
	Average			2		
	Percentage			50%		
	Hypothetical Average			0.1		
	Gap			50%		

Table 3. Social Effects

Third Dimension: Social Effect		Scale				
N0	The company has :	Totally Applied	Partially Applied	Somewhat applied	Poorly Applied	Not Applied
1	High interest in supporting worker creativity in developing product quality.		x			
2	High speed to meet customers' needs.			x		
3	Qualified staff to deal with unplanned and unexpected events		x			
4	High flexibility in exchanging information with all the factory departments and the distribution and scheduling of tasks to improve the processes performance				X	
5	The ability to make products that meet the continuous changing needs of customers			X		
	Weight	4	3	2	1	0
	Frequency	0	2	2	1	2
	Score	0	6	4	1	0
	Average			2.2		
	Percentage			55%		
	Hypothetical Average			0.11		
	Gap			45%		

Table 4. Environmental Effects

Fourth Dimension: Environmental Effect		Scale				
N0	The company has :	Totally Applied	Partially Applied	Somewhat applied	Poorly Applied	Not Applied
1	Eco-friendly products		X			
2	An information system for measuring and controlling emissions associated with all manufacturing operations					X
3	The ability to reduce or to remove the effects resulting from the energy consumed in the production processes			X		
4	The ability to fully recycling the returned products to keep a green environment			X		
5	A production line is not causing any kind of pollution for soil, air, and water		x			
6	alternative raw materials that can be used to produce the same products					X
	Weight	4	3	2	1	0
	Frequency	0	2	2	0	2
	Score	0	6	4	0	0
	Average			1.67		
	Percentage			42%		
	Hypothetical Average			0.07		
	Gap			58%		

4. General review of results

After checking the level of the smart production dimensions in the company and analyzing the actual conditions in the factory subject to our study, we summarize the results in the figure appearing below.

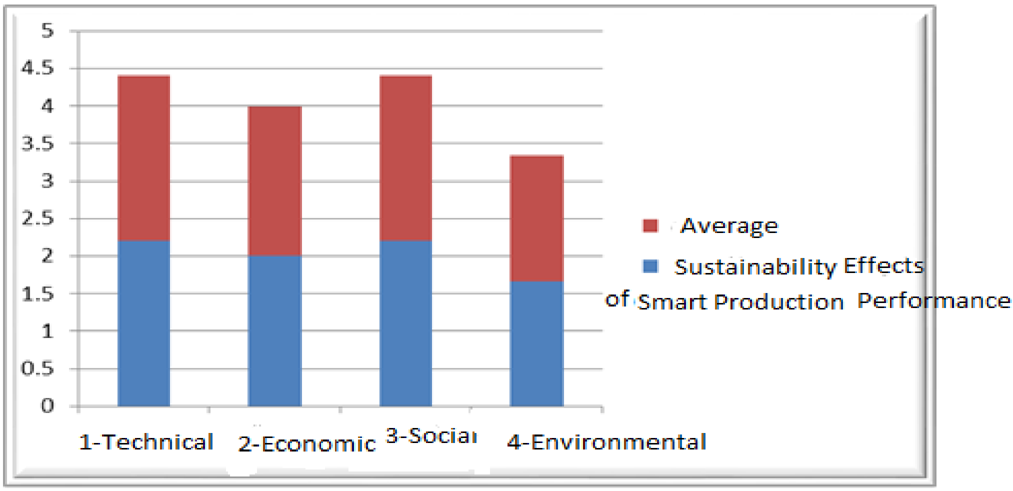

Figure 1. Summary of checklists' results for determining the effects of the sustainability of smart production performance

The results of the checklists in the above tables show that the dimensions in the technical and social effects have similar levels (2.2) and are the highest in the checklist. This indicates that the company has an acceptable level of technical and social commitment that has a positive impact on society in general. Also, the economic effects on a rate of (2) entail a weakness in the company's response to meet the customer's needs, the change in the characteristics of the product and raw materials, and acceptable production flexibility. In terms of the environmental impacts dimension, the average is 1.67 which means that the company does not follow the environmental legislations and is weak in preserving natural resources, disposing of materials, and waste in an environmentally sound manner. Therefore, all production processes must be developed and automated. This requires a wide use of IT software pieces and applications in this factory to be closer to smart production.

5. Conclusions and recommendations

The following includes a presentation of a set of conclusions based on the results of the study. They are followed by some recommendations to provide models that contribute to the scientific and cognitive advancement of the studied reality of the factory.

5.1. Conclusions

1. The study showed that the factory does not have an intelligent production line. Rather, it has a production line that enables the company to achieve an acceptable level of application that produces some effects of sustainable production.
2. The factory offers environmentally friendly products by manufacturing an electrical energy production with the least environmental damage.
3. The factory lacks flexibility because it is limited to a specific type of production; it cannot cope with changes in customer demand.
4. The factory cannot monitor and diagnose defects and breakdowns through an integrated system that works together as a whole combining electronic and human systems. Rather, it uses human efforts for detecting and fixing breakdowns and stops where technicians use efficient tools for fixing and repairing.
5. The plan pays a lot of attention to the production of solar panels with an acceptable level of sustainability. However, we cannot conclude that its performance is environmentally sustainable.

5.2. Recommendations

1. The factory should develop its product line and move to an intelligent production system. Managers should focus on eliminating the constraints and restrictions impeding flexibility in their production line processes.
2. Responsibility must be assumed to raise the awareness of using environmentally friendly products to increase profits and obtain market share.
3. The company must empower workers continuously in the factory to increase their knowledge and coordination between machines and human resources to design, develop and maintain the smart programs and software pieces.
4. More investments must be done to encourage the use of solar cells and sustain the productive performance of the plant.
5. The management is recommended to ensure the availability of alternative raw materials for production. In addition, it should reduce wasting resources and energy pollution, and gas emissions. The natural environment must also be protected. All this is the core of the smart production philosophy.
6. Building an environmental monitoring system for all workstations, not just in the final workstation, but also in the sustainable environmental production that includes an environmental strategy that should be applied along the production line.
7. The concern about natural resources enhances the development of the manufacturing operations by transferring the smart environmental philosophy of smart production to the consumer. This ensures the sustainability of cooperation with the beneficiaries to preserve a green environment free from any kind of pollution.

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