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THE EFFECT OF AGILE MANUFACTURING STRATEGY ON TOTAL PRODUCTIVE MAINTENANCE

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Abstract:

This research aims to analyze the impact of effective manufacturing strategy on total productive maintenance. Effective manufacturing focuses on improving product quality, increasing productivity, and reducing costs, while total productive maintenance focuses on maintaining machines and equipment in good operational condition and high efficiency. The research seeks to understand how to achieve integration between these two dimensions to achieve excellent performance in manufacturing operations. The study was conducted using the General Company for Battery Manufacturing as a research community, with a sample size of 60 individuals. The research found significant results, including the fact that using an effective manufacturing strategy leads to improving the effectiveness of total productive maintenance by contributing to maintenance execution, improving maintenance scheduling and resource planning in manufacturing and energy. The integration between effective manufacturing strategy and total productive maintenance is achieved through the support and commitment of top management to continuous improvement, forming specialized maintenance teams, fostering a maintenance awareness culture, predicting failures, and training and educating employees on the benefits and advantages of total productive maintenance.

Keywords: Agile Manufacturing Strategy, Information Technology, Intelligent Workers, Corporate Partners, Total Productive Maintenance, Autonomous Maintenance, 5S, Continues Improvement, Quality Maintenance.

Introduction:

Effective manufacturing strategy and total productive maintenance are important concepts in the field of production and operations management. They focus on improving manufacturing processes and maintaining machines, equipment, and production systems with high efficiency. This research aims to study the impact of effective manufacturing strategy on total productive maintenance and how to achieve integration and harmony between them. This integration leads to improving process efficiency and coordination between technical and managerial aspects in reducing production downtime and improving resource planning. To cover these concepts and arrive at accurate results, a sample of 60 participants was used. Based on the aforementioned, the current research is divided into four main axes:
Axis 1: Research methodology
Axis 2: Theoretical foundation of the research
Axis 3: Practical aspect and discussion of results
First Axis: Research Methodology

1. Research Problem: Effective manufacturing strategy is a methodology that focuses on improving product quality, increasing productivity, and reducing costs through streamlining processes and optimizing resource utilization. On the other hand, total productive maintenance is a comprehensive approach to maintaining machines, equipment, and the workplace by conducting maintenance activities and ensuring cleanliness and organization. The research problem can be identified by addressing the following questions: a. Does the researched company have a clear understanding of effective manufacturing strategy? b. Does the company recognize the importance of implementing total productive maintenance principles for workplace preservation? c. Does the company prioritize the role of effective manufacturing strategy in achieving the principles of total productive maintenance?
2. Research Significance: The significance of the research stems from the importance of the variables used in the current study. These variables are important and contemporary concepts in the field of manufacturing operations management. The significance of the research is manifested in: a. Clarifying the concept of effective manufacturing strategy and total productive maintenance within the researched company. b. Highlighting the impact of effective manufacturing strategy on total productive maintenance.

3. Research Objectives: The main objective of the research is to determine the real role and impact of effective manufacturing strategy on total productive maintenance. The sub-objectives include: a. Identifying the direct role and impact of effective manufacturing strategy on total productive maintenance. b. Understanding the indirect role of effective manufacturing strategy in promoting and implementing total productive maintenance principles.
4. Research Hypotheses: The research is based on four main hypotheses: a. The dimensions of effective manufacturing strategy (strategic planning of human resources, information and communication technology, and united partners) have a statistically significant impact on the 5S variable. b. The dimensions of effective manufacturing strategy have a statistically significant impact on the self-maintenance variable. c. The dimensions of effective manufacturing strategy have a statistically significant impact on the continuous improvement variable. d. The dimensions of effective manufacturing strategy have a statistically significant impact on maintenance quality.
5. Data Collection Methods: The theoretical aspect of the research is based on various Arabic and English sources, including books, theses, and dissertations. The field aspect was covered through field observation, personal interviews, data classification, and the use of questionnaires as the primary research tool, with a sample size of 60 participants.
6. Research Method: The research is based on a descriptive-analytical methodology that aligns with the nature of the research topic.
7. Research Limitations: The geographical scope of the research is limited to the General Company for Battery Manufacturing, located in Baghdad. In terms of time limitations, the research period extended from May 27, 2023, to July 5, 2023.

Second Axis: Theoretical Foundation of the Research

First: The Concept of Agile Manufacturing Strategy and its Definition

Agile manufacturing strategy is a modern cognitive approach in the field of production and operations. It combines the expertise, knowledge, and modern technology to achieve collaborative efforts in meeting the needs and desires of customers for high-quality products (Dischler & Hug, 2011:27). Hallgren and Olhager (2009:979) defined it as "the ability to survive, grow, and succeed in a competitive environment of continuous and unexpected change through quick and efficient response to market demands, driven by customer-designed products and services." It is a term applicable to economic units that establish operations, tools, and necessary training to enable rapid response to customer needs and market changes, while controlling costs and ensuring quality (Koh & Wang, 2010:156). It is also defined as a manufacturing technology that focuses on unifying and integrating the concepts of flexibility and computer-integrated manufacturing systems, utilizing them to develop ideas and identify capabilities that emerge from future vision (Abduljabbar & Hassan, 2012:14). It is a system adopted by organizations that have high responsiveness to customer tastes and preferences based on their physical and human capabilities (Kumar & Dev, 2015:1). The effective manufacturing strategy relies on waste-free manufacturing, incorporating individual ideas, creating opportunities through new technologies, and integrating design and manufacturing as a single entity in developing customer-driven interaction methods with suppliers (Chikwendu, 2020:11763).

Advantages of Implementing Effective Manufacturing Strategy

There are several advantages that industrial organizations gain from implementing effective manufacturing strategy (Gunasekaran & Yusuf, 2002:1362):

1. Achieving customer satisfaction.
2. Reducing manufacturing costs.
3. Streamlining non-value-added activities.
4. Rapid development of new products.
5. Competitive capability in manufacturing industries.
6. Increasing market share.

Principles of Total Productive Maintenance

Total Productive Maintenance (TPM) is based on the following principles:

1. 5S Technique (S5): This technique is applied by management to reduce waste and eliminate unnecessary activities in the workplace environment, following international standards. It ensures workplace safety (Boca, 2015:1297). It is also known as a technique for organizing and maintaining high efficiency of equipment and machines in the workplace, as well as ensuring high quality (Sharma & Singh, 2015:820). This technique includes five steps for organizing the workplace:

a. Seiton (Organization): This step focuses on eliminating unnecessary items in the workplace. It is implemented through the red tag strategy, which helps identify unnecessary parts and determine their usefulness.

b. Seiri (Sorting): This step involves organizing necessary items to make them easily accessible for anyone. It emphasizes the idea that anyone should be able to understand the arrangement of items in the workplace.

c. Seiso (Cleaning): This step focuses on cleanliness, which ensures comfort, safety, and better visibility in the workplace. It reduces retrieval time and ensures higher product quality. Daily cleaning is necessary to maintain a clean, desirable, and safe working environment, which boosts morale and increases productivity, while focusing on value-adding activities.

d. Seiketsu (Standardization): Through this step, the work team identifies ways to improve practices in the workplace. Standardization aims to find the best practices and ensure that every team member uses the same practices in the same way.

e. Shitsuke (Discipline): This step emphasizes the need to reinforce and encourage employees to continue making improvements in their work areas on a regular basis. Continuous improvement should become an expectation and a routine activity in the workday. Halting the improvement process will lead to a deterioration of the work environment.
2. Autonomous Maintenance: This refers to operators performing routine maintenance tasks for machines and equipment, such as inspection, cleaning, and lubrication.
3. Planned Maintenance: It includes the set of operations performed to repair machines according to a predetermined schedule set by machine manufacturers or experienced technicians responsible for maintenance (Al-Hishlmon, 2017:22).
4. Maintenance Quality: It ensures that the product meets specified standards, achieving customer satisfaction and delight. This is accomplished through pre-detection of any defects in machine parts that may affect product quality. Maintenance quality is based on the principle that a well-maintained machine produces a perfect product (John, 2009:34).
5. Education and Training: Training and education are essential for operators to perform self-maintenance and preventive maintenance on machines and equipment. It is necessary for users to have multi-skills and the flexibility to perform multiple functions effectively. It also boosts employee morale and the desire to perform all tasks efficiently (Melesse & Ajit, 2012:4).
6. Continuous Improvement: It is a Japanese philosophy of continuous improvement and working on the development of processes, individual activities, machines, materials, and production methods continuously to achieve complete perfection through continuous improvements in the company's production processes (Quality, 2004:181).
7. Early Equipment Management: It involves activities such as planning and designing for a new factory or new equipment, resulting in a highly reliable, maintainable, economical, operable, and flexible facility, considering maintenance information and new technologies (Sharma et al., 2012:860).
8. Safety, Health, and Environment Management: It provides a safe working environment where no harm occurs due to production procedures and operations, aiming for zero accidents and zero harm to health (Kocher & Kumar, 2012:46).
9. Total Productive Maintenance Management: The principle of total productive maintenance should be implemented to improve productivity and enhance management efficiency by identifying and eliminating losses. It includes analyzing processes and procedures that increase management automation. The application of total productive maintenance should start after implementing the four principles of total productive maintenance: autonomous maintenance, planned maintenance, continuous improvement, and maintenance quality (Mfowabo, 2006:29).

Components of Effective Manufacturing Strategy

1. Information Technology: Information technology is the fundamental support in the process of effective manufacturing as it provides the necessary data and information for performance in all areas of production, activities, and operations within the organization (Krajewski et al., 2010:114).
2. Intelligent Workers: These are individuals with experience and cognitive skills, also known as knowledge workers, who add value to their organization's products. They possess a clear understanding of their work, can handle fluctuations, and contribute to the organization's growth. They have strategic thinking abilities, continuous learning skills, and a spirit of creativity and innovation that drives them to expand their vision to deliver better products and services for the organization. Intelligent workers are often smart, creative, confident, and interested in planning their time. It is possible for a worker to be more intelligent and knowledgeable in their field than their manager (Durbin, 2012:387).
3. Corporate Partners: Active employee participation requires the formation of various teams aimed at positively influencing decision-making processes and the strategic direction of the organization through quality circles, cross-functional teams, and self-managed teams. Employees are empowered to make decisions and monitor their performance in their work (Daft, 2010:206). Additionally, companies should establish contracts with suppliers to provide the necessary raw materials for production processes (Slack & Johnston, 2004:4).

Total Productive Maintenance (TPM)

Many companies seek to integrate the concepts of total quality management with preventive maintenance and form a TPM approach, which includes the concept of reducing breakdowns through employee involvement and the use of excellent maintenance records. TPM includes the following (Heizer & Render, 2006:664):

1. Designing reliable machines that are easy to operate and maintain.
2. Emphasizing the total initial cost when purchasing machines to ensure service and maintenance are within the cost.
3. Developing preventive maintenance plans that benefit from the best practices of operators and maintenance departments.
4. Training employees on machine operation and maintenance.

TPM is a system that involves the participation of all employees in the organization, from top-level management to production line workers, in machine maintenance activities. It includes activities such as breakdown maintenance, preventive maintenance, and predictive maintenance to improve the efficiency, effectiveness, and productivity of machines and equipment in the factory (Al-Saman & Wahab, 2012:5). It serves as an early management approach for machines and equipment through training and involving operators in maintenance activities to improve equipment efficiency and effectiveness, as well as reduce unnecessary equipment downtime (Mohammed, 2020:37).

Third Axis: Descriptive Statistics and Test of the Normal Distribution of Data

Descriptive Statistics for Variables

This section is dedicated to presenting the results of descriptive statistics for the research variables, including their dimensions and corresponding items. This analysis was conducted using various statistical tools, such as measures of central tendency, represented by the mean, to answer each item in the questionnaire representing the dimensions of the variables. The mean is the primary data collection tool in this research. Measures of dispersion, such as standard deviation and coefficient of variation, were also used to determine the relative importance of the questionnaire items and the variability of the researched dimensions for each variable. The statistical description also includes determining the response level for each item.

Additionally, the normal distribution test was conducted for the dimensions of the research variables to ensure the presence of the condition of linear relationships between the independent and dependent variables. This was done based on a review of the literature on statistics and in accordance with the mentioned regression methods. This was necessary because the study includes latent variables that cannot be directly measured except through their dimensions expressed in the questionnaire. The following is a detailed presentation of the results of the statistical description of the dimensions of the research variables.

First: Agile Manufacturing Strategy

1. Strategic planning for human resources

The results of the descriptive statistics for this dimension, measured through five items, are shown in Table 1. The fourth item (formation of teams of experienced and knowledgeable workers to perform a specific task) achieved the highest relative importance due to a significant decrease in the standard deviation value (0.841), indicating low variability in the sample responses. Additionally, the mean value (4.111) for this item was higher, approaching a very high response level. These results led to a decrease in the coefficient of variation to its minimum value (0.204) compared to the other items in the dimension, indicating a high agreement among the respondents regarding the content of this item. The item with the lowest relative importance, the fifth item (allocation of incentives and reliance on financial and non-financial measures to encourage employees to discover and learn new skills), had an increase in the standard deviation value (1.014) and a decrease in the mean value (3.793) compared to the other items in this dimension. Consequently, the coefficient of variation increased to (0.267), indicating less agreement on the content of this item. As for the other items in this dimension, the analysis method aligns with the context, which varied in the descriptive statistics results between the mentioned highest and lowest levels of relative importance, as shown in Table 1, based on the coefficient of variation resulting from dividing the standard deviation by the mean.

Table 1. Describing Strategic planning for human resources

No.	Describing Tools / Items	Mean	St.dev	c.v.	approval	Priority
1	The company seeks to empower employees to accomplish their work by involving them in making strategic decisions.	3.928	0.821	0.209	High	2
2	Delegating authority to employees to solve major production problems.	3.865	0.932	0.241	High	3
3	Facilitating communication between employees and senior management	3.738	0.913	0.244	High	4
4	Forming teams of experienced, knowledgeable and skilled employees to carry out a specific task.	4.111	0.841	0.204	High	1
5	Allocating incentives and relying on financial and non-financial measures to encourage employees to discover and learn new skills.	3.793	1.014	0.267	High	5
	The average for this dimension.	3.887	0.552	0.142	High	

1. Information and Communication Technology

The results of the descriptive analysis presented in Table (2) after measuring it with five paragraphs about achieving the fourth paragraph (the company relies on manufacturing resource planning (MRP II), including energy planning) have the highest relative importance due to the lowest standard deviation value (0.668). Which indicates less dispersion in the study sample responses. On the other hand, for its high arithmetic mean value of (4.222), which indicates a very high level of response. These results led to a reduction in the value of the difference coefficient to its minimum (0.158) compared to the rest of the paragraphs. Which indicates a high agreement among respondents about the content of this paragraph. As for the lowest relative importance, it was in paragraph two (the company is working on designing an integrated information system for the supplier, distributor and / or end customer) due to the high standard deviation value (0.972), as well as a decrease in its arithmetic mean value to its minimum level (3.396) compared to other paragraphs, and at a moderate response level. This leads to an increase in the difference coefficient value to its highest level (0.286). Indicating less agreement about what is mentioned in this paragraph. As for the rest of the paragraphs related to this dimension, this analysis method applies to this pattern, which varied in statistical rank results between these two extremes of relative importance shown in Table (2) according to the variance coefficient value.

Table 2. Information and Communication Technology Describing

No.	Describing / Tools / Items	Mean	St.dev	c.v.	approval	Priority
1	The company relies on computer-aided design, manufacturing and processing	3.952	0.808	0.204	High	3
2	The company is working on designing an integrated information system for the supplier, distributor and/or end customer	3.396	0.972	0.286	High	5
3	The company is working on designing an integrated information system between different departments in the factory and/or business unit	3.674	0.892	0.243	High	4
4	The company relies on manufacturing resource planning (MRP II), including energy planning	4.222	0.668	0.158	Very High	1
5	The company uses modern methods to apply science and technology to develop and improve products or information	4.103	0.788	0.192	High	2
	Average for the dimension	3.869	0.507	0.131	High	

1. Corporate Partners

According to the results of the analysis of the description for this dimension shown in Table (3), which was also measured through five paragraphs, it was found that the fourth paragraph (the company responds effectively to new competitive threats and market opportunities) has the highest relative importance due to the low value of the standard deviation (0.763) and a high value of the mean (4.023) compared to other paragraphs expressing this dimension, while at the same time at a high response level. Those results led to a decrease in the value of the difference coefficient to its minimum (0.189) for the two mentioned reasons, confirming a high agreement among respondents about the content of this paragraph. As for the fifth relative importance, it was achieved in the first paragraph (company employees seek to adopt teamwork in accomplishing their activities) due to the high value of its standard deviation (0.996) primarily, despite not decreasing its mean value much (3.801), and at a high response level. This was mainly due to the high standard deviation being the main reason behind the increase in the dispersion coefficient in sample responses to its highest level (0.262), indicating less agreement on what is stated in this paragraph. This method can be repeated in analyzing the rest of the paragraphs of this dimension.

Table 3. United Partners Describing

No.	Describing / Tools / Items	Mean	St.dev	c.v.	approval	Priority
1	Company employees seek to adopt teamwork in accomplishing their activities.	3.801	0.996	0.262	High	5
2	The company management believes in the importance of self-monitoring and holds	3.833	0.864	0.225	High	3

	employees responsible for the results of .their work					
3	The company offers new and diverse methods to develop work programs compared to competitors..	3.809	0.873	0.229	High	4
4	The company effectively responds to new competitive threats and market opportunities	4.023	0.763	0.189	High	1
5	The company is looking for new ways to attract customers' attention and retain them	3.920	0.835	0.213	High	2
	The average for this dimension.	3.879	0.568	0.146	High	

2. Total Productivity maintenance

1. 5S

Table (4) reveals the results of the descriptive statistics for this dimension, which was expressed in five paragraphs. The third paragraph achieved the highest relative importance with a difference coefficient (0.182), an average of (3.892), and a standard deviation of (0.711), which was the main reason for reducing the value of the difference coefficient in this paragraph and which expressed less dispersion in the respondents' views, with a high level of response reflecting a high agreement among sample members on this paragraph. On the other hand, the lowest relative importance was in the first paragraph (excluding all unnecessary things and retaining only what is necessary) with an average of sample answers to this paragraph (3.857) at a high level for the answer, with the highest standard deviation (0.855) compared to other paragraphs in this dimension, and thus an increase in the dispersion coefficient in sample answers to the highest extent (0.221) at the level of credibility dimension, indicating limited agreement among them. As for other paragraphs, this pattern of analysis applies to all of them according to their relative importance, which fluctuated in statistical description results between the highest and lowest levels mentioned above for relative importance according to difference coefficient ratios.

Table 4. 5S Describing

No.	Describing Tools / Items	Mean	St.dev	c.v.	approval	Priority
1	Exclude all unnecessary things and keep only what is necessary.	3.857	0.855	0.221	High	5
2	Work on keeping tools and necessary items in their proper place and arranging them in a way that makes them easy to access when needed.	3.881	0.733	0.188	High	2
3	The company is committed to continuously organizing and cleaning the workplace.	3.892	0.711	0.182	High	1
4	Establish rules and procedures that ensure the organization and cleanliness of the workplace so that it becomes productive and comfortable by repeating what was mentioned in the above three points.	3.976	0.774	0.194	High	3
5	mployees are committed to applying the new work rules, standards, and procedures related to the workplace.	3.785	0.744	0.196	High	4
	The average for this dimension	3.876	0.540	0.139	High	

2. Autonomous Maintenance

The results of the analysis for this dimension shown in Table (5) after being measured through five paragraphs resulted in achieving the third paragraph (arranging all parts and units that need cleaning) as the most important relative importance due to the low value of the standard deviation in it (0.691), which indicates the limited variability of sample responses and at the same time with an increase in the value of the arithmetic mean to its highest limit (4.047) compared to the rest of the paragraphs after commercial capabilities, at the same time with a high level of response, which led to a decrease in the value of the difference coefficient to its minimum (0.170), indicating a clear consensus among respondents about the content of this paragraph. On the other hand, the lowest relative importance was in the first paragraph (training and educating workers on the benefits and advantages of comprehensive productive maintenance) due to an increase in the value of standard deviation to (1.031) and a decrease in arithmetic mean at the same time (3.444), so it was lower compared to other paragraphs with a high level of response, and then an increase in the value of the difference coefficient in sample responses to its highest level (0.299), confirming that there is a greater difference between sample responses about the content of the first paragraph, and this method can be repeated for analyzing other paragraphs of this dimension.

3. Continuous Improvement

Table (6) shows the results of the statistical description of this dimension as expressed by the respondents of the sample, which shows that the first relative importance was achieved in the fifth paragraph (continuous training of workers on various activities and based on workers' performance results as a basis for continuous improvement) thanks to the low value of the standard deviation (0.671), which indicates limited variability in sample responses and at the same time with an increase in the value of the arithmetic mean to its highest limit (4.047) at a high level of response, which led to a decrease in the value of the difference coefficient to its minimum (0.178), confirming high consistency among sample responses regarding the content of this paragraph. As for the last relative importance, it was in the second paragraph (management forms work teams for continuous improvement to avoid errors and introduce improvements) due to an increase in the value of standard deviation (0.888) compared to other paragraphs of this dimension and with an arithmetic mean (4.055) at a high level of response, thus an increase in the value of the difference coefficient in sample responses to its highest level (0.219), indicating greater dispersion among respondents about the content of this paragraph. Of course, this method can be repeated for analyzing other paragraphs of this dimension.

Table (6) Continuous Improvement Describing

No.	Describing Tools / Items	Mean	St.dev	c.v.	approval	Priority
1	A plan is developed to implement small improvements to increase overall efficiency of laboratory machines and equipment.	3.778	0.757	0.200	High	4
2	The management forms work teams for continuous improvement to avoid errors and introduce improvements.	4.056	0.882	0.219	High	5
3	The management puts forward a specific action plan for human and material continuous improvement requirements.	3.777	0.736	0.194	High	3
4	Continuous improvement tools are used in technical areas of maintenance such as: (productive maintenance analysis, why analysis, waste summary, improvement reports, etc.).	3.809	0.734	0.192	High	2
5	Workers are trained continuously on various activities and based on workers' performance results as a basis for continuous improvement.	3.769	0.671	0.178	High	1
	Average overall dimension.	3.838	0.536	0.139	High	

4. Quality maintenance

Table (7) shows the results of the statistical description of the Quality maintenance dimension according to the opinions of the sample, which shows that the first paragraph (determining the operational conditions related to machines and equipment that cause defects in product quality) has the highest relative importance due to the decrease in standard deviation (0.732), which indicates limited variation in sample responses, coinciding with a noticeable increase in the mean (4.007) and a high level of response. These results led to a decrease in the coefficient of variation (0.182), reflecting clear agreement among respondents on the content of the first paragraph. As for the last relative importance, it was in the second paragraph (the company management supports quality assurance activities for maintenance management activities and documentation of operational conditions when defects occur in the process) due to an increase in standard deviation to (1.045) and an arithmetic mean (4.055) and a high level of response, and hence an increase in the coefficient of variation in sample responses to its highest level (0.257), indicating greater variation among sample members about the content of this paragraph. This method of analysis can also be repeated for other paragraphs related to this dimension, and thus this level of analysis as well.

Table 7. Quality maintenance Describing

No.	Describing Tools / Items	Mean	St.dev	c.v.	approval	Priority
1	Determining the operational conditions related to machines and equipment that cause defects in product quality.	4.007	0.732	0.182	High	1
2	The company management supports quality assurance activities for maintenance management activities and documentation of operational conditions when defects occur in the process.	4.055	1.045	0.257	High	5
3	The maintenance department works on identifying the parts and using the raw materials that affect the quality of the product in machines and equipment.	4.023	0.753	0.187	High	2
4	Determine the source of defects in the product and determine the size and frequency of defects at each stage of product quality measurement.	3.857	0.845	0.219	High	3
5	Maintenance work is carried out for machines and equipment without errors occurring, and spare parts that comply with specifications are used.	3.825	0.839	0.219	High	4
	The overall average for the dimension.	3.954	0.589	0.149	High	

Before starting the procedures for testing the hypotheses of this research, it must be verified that the dimensional data are normally distributed. Looking at Table (8) for the results of the normal distribution test of the data using the (Kolmogorov-Smirnov) test and at the level of each dimension of the variables under study that fall within the models of hypothesis testing as independent or dependent variables. It was found from the mentioned table that all those dimensions' data have met the normal distribution condition after they were significant ($p>.05$). This ensures the possibility of using linear regression models in testing hypotheses of this research for their possession of the quality of being informative. Also, the hypothesis of normal distribution is formulated as follows:

H_o: Dimensional data are normally distributed **(H_0: $P=0$)**
H_1: Dimensional data are not normally distributed **(H_0: $P\neq0$)**

Table (8) Results of normal distribution test for variable dimensions Test type and characteristics
Open in browser

Test type and characteristics / Variables and dimensions	Kolmogorov-Smirnov		
	Test statistics	**Significance value**	**Test significance**
	Agile Manufacturing Strategy		
SPHR	0.079	0.200	Insignificant
ICT	0.094	0.074	Insignificant
UP	0.075	0.200	Insignificant
	Total Productivity maintenance		

5S	0.081	0.200	Insignificant
AM	0.086	0.200	Insignificant
CI	0.076	0.200	Insignificant
QM	0.073	0.200	Insignificant

Hypothesis testing

The research hypotheses were tested using multiple linear regression models using ready-made statistical programs (SPSS24 and AMOS24), and the results were as follows: First hypothesis test: The results of this hypothesis test, as shown in Table (9), showed the significance of two dimensions, namely SPHR 29, P = 0.003) = β) and UP (.30, P = 0.000 = β) among the dimensions of the Agile Manufacturing Strategy variable in the 5S dimension. The significant effect of ICT dimension (.09, P> 0.05 = β) in the 5S dimension was not proven. As for the total explanatory power of the model in light of the value of the interpretation or determination coefficient, it reached (R2 = .36) with complete statistical significance (P = 0.000), which describes the contribution of the two significant dimensions by (36%) in the variation of the 5S dimension, and the remaining percentage (74%) is due to other variables that were not included in this test model.

Table (9) Results of the first hypothesis test

Statistical indicators / **Details**	B	|t|	P>|t|	R2	F	P>F
Intercept (constant) B_0	1.422	3.216	.002	0.36	48.32	.000
SPHR ----> 5S	.29	3.039	.003			
ICT ----> 5S	.09	.019	.993			
UP ----> 5S	.30	3.409	.000			

and Figure (1) shows a graphical embodiment of the relationship between the dimensions of the Agile Manufacturing Strategy variable and the 5S dimension.

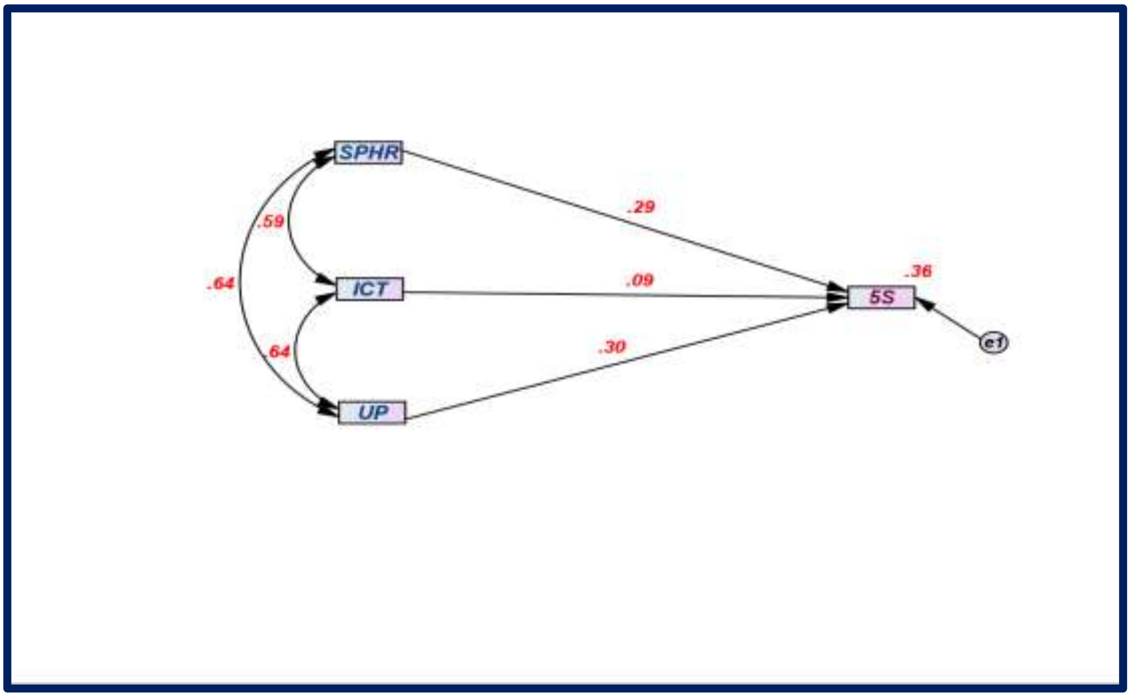

Figure (1) Regression paths of the relationship between the dimensions of the Agile Manufacturing Strategy variable and the 5S dimension

Testing the second hypothesis:

The results of testing this second hypothesis, which is shown in Table (10), showed the significance of the dimensions, which are both the SPHR dimension (36, P=0.000)=β) and the ICT dimension (18, P=0.039) =β) and the UP dimension (.31, P=0.002=β) among the dimensions of the Agile Manufacturing Strategy variable in the AM dimension. As for the total explanatory power of the model in light of the value of the interpretation or determination coefficient, it reached (R2=.55) with complete statistical significance (P=0.000), which describes this value as the contribution of the three significant dimensions by (55%) in the variation of the AM dimension, and the remaining percentage (45%), is due to other variables that were not included in this test model.

Table (10) Results of testing the second hypothesis

Statistical indicators / Details	B	|t|	P>|t|	R2	F	P>F
Intercept (constant) Bo	1.015	3.062	.002	0.55	68.41	.000
SPHR ----> AM	.360	3.153	.000			
ICT ----> AM	.181	2.088	.039			
UP ----> AM	.314	3.903	.002			

And Figure (2) shows a graphical representation of the relationship described in hypothesis two regarding the relationship between dimensions of Agile Manufacturing Strategy variable and AM dimension.

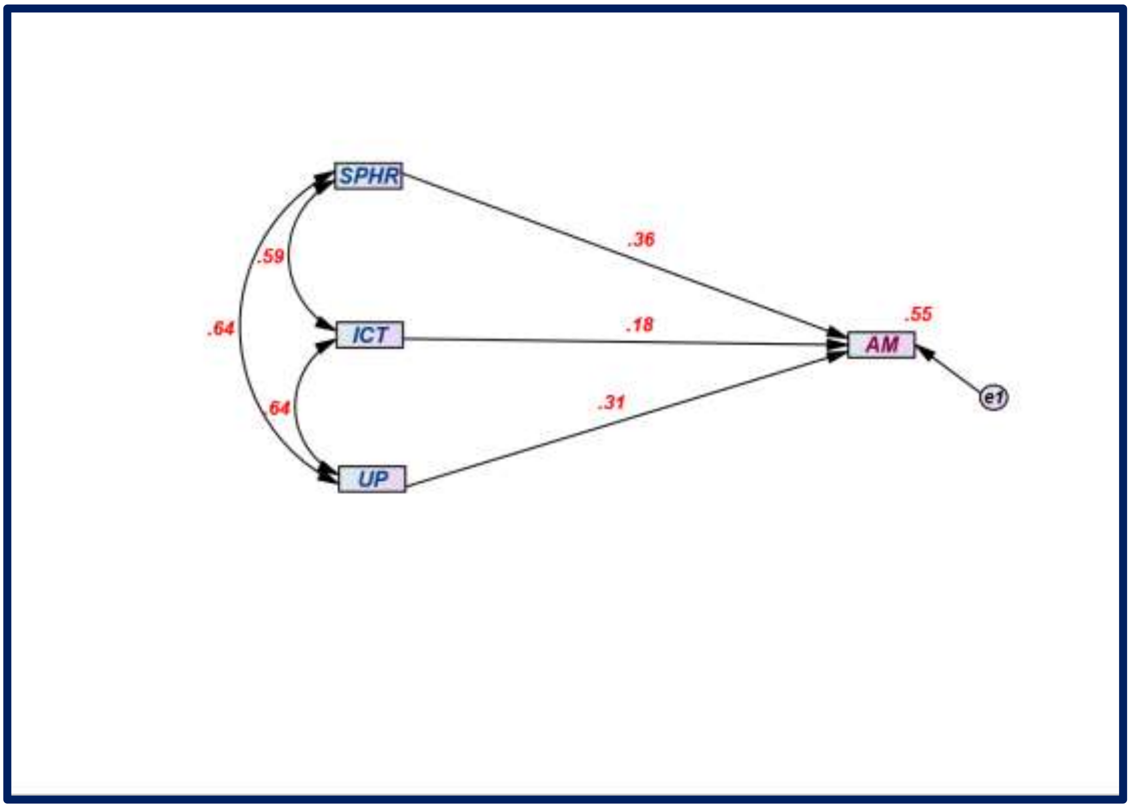

Figure (2) Regression paths of the relationship between dimensions of Agile Manufacturing Strategy variable and AM dimension

Testing the third hypothesis:

The results of testing this third hypothesis, which is shown in Table (11), showed the significance of two dimensions, which are both the ICT dimension (15, P=0.046)=β) and the UP dimension (.56, P=0.000=β) among the dimensions of the Agile Manufacturing Strategy variable in the CI dimension. The significant effect of the SPHR dimension (.71, P>0.05=β) in the CI dimension was not proven. As for the total explanatory power of the model in light of the value of the interpretation or determination coefficient, it reached (R2=.51) with complete statistical significance (P=0.000), which describes this value as the contribution of two significant dimensions by (51%) in the variation of the CI dimension, and the remaining percentage (49%), is due to other variables that were not included in this test model.

Table (11) Results of testing the third hypothesis

Statistical indicators / Details	B	|t|	P>|t|	R2	F	P>F
Intercept (constant) Bo	**.915**	**2.259**	**.031**	**0.51**	**58.30**	**.000**
SPHR ----> AM	**.071**	**1.153**	**.172**			
ICT ----> AM	**.152**	**2.088**	**.046**			

UP ----> AM	**.561**	**3.903**	**.000**			

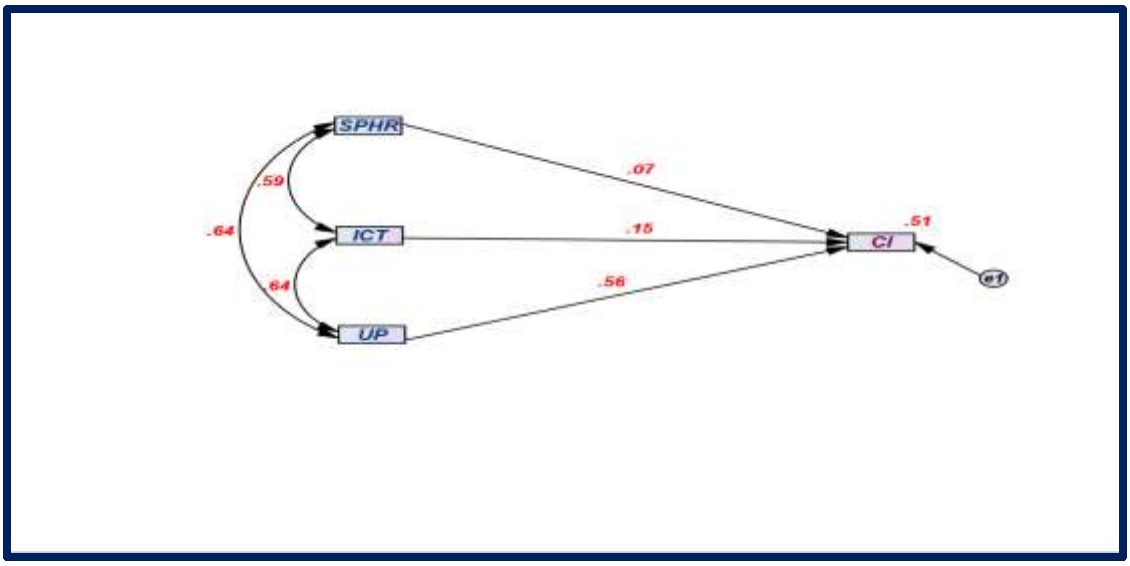

Figure (3) the regression paths of the relationship between the dimensions of the Agile Manufacturing Strategy variable and the CI dimension

Test of the fourth hypothesis:

The results of testing this second hypothesis, which is shown in Table (12), showed the significance of the dimensions, which are both SPHR 26, P = 0.002) = β) and UP (.35, P = 0.000 = β) among the dimensions of the Agile Manufacturing Strategy variable in the QM dimension. As for the total explanatory power of the model in light of the value of the interpretation or determination coefficient, it reached (R2 = .38) with complete statistical significance (P = 0.000), which describes this value as contributing to the three significant dimensions by (38%) in the variation of the QM dimension, and the remaining percentage (62%) is due to other variables that were not included in this test model.

Table (12) Results of testing the fourth hypothesis

Statistical indicators / **Details**	B	|t|	P>|t|	R2	F	P>F
Intercept (constant) B_O	1.205	2.932	.951	0.38	48.20	.000
SPHR ----> AM	.264	3.153	.002			
ICT ----> AM	.104	1.388	.171			
UP ----> AM	.354	3.903	.000			

DISCUSSION OF THE RESULTS:

The research sample company is constantly interested in forming work teams to face and solve the problems facing the production process and its persistent pursuit of increasing production efficiency. The company also relies on resource planning foundations in planning processes to meet its energy requirements. The results confirmed the company's continued training of workers at all levels and its adoption of the continuous improvement process to raise the level of employee performance, which is considered the basic standard for evaluating employees. Also, the company seeks to diagnose the work environment specific to production operations and provide suitable conditions for it, which can cause a reduction in product quality and exclude all unnecessary things and retain only what is necessary. The dimensions of the Total Productivity maintenance variable varied according to the dimensions of the Agile Manufacturing Strategy variable. It can be concluded that if the conditions for applying Agile Manufacturing Strateg improve and its application stages increase in production operations, this will lead to additional improvement in the Total Productivity maintenance variable, which was interpreted by the significance of the models for the determination coefficient values in the four tests, but within the limits of significance of beta regression coefficients in the mode

REFERENCES.

1. Abdul Jabbar, H. A., & Hassan, A. S. (2012). The role of effective manufacturing system requirements in achieving product innovation: A theoretical framework. Research in Business Administration, College of Management and Economics, Tikrit University.

2. Abdul Wahab, A. H. (2020). The impact of applying total productive maintenance on manufacturing performance: A case study of the National Company for Sponge and Plastic Industry. Al-Sada Journal for Legal and Political Studies, 4, 2710-2783.
3. Al-Hishlamoun, Y. H. (2017). The impact of quality costs on competitive advantage: A survey study in the General Company for Battery Industry (Unpublished master's thesis). Technical College of Management, Technical Education Authority, Baghdad, Iraq.
4. Al-Lami, G. Q. (2008). Contemporary techniques and systems in operations management (1st ed.). Ithraa Publishing and Distribution.
5. Al-Mousawi, A. N., & Al-Aqabi, M. A. (2018). The possibility of applying 5S technique to implement effective manufacturing strategy and achieve customer satisfaction: An applied research in the General Company for Electrical and Electronic Industries Journal of Kufa College, 3(2), 157-184.
6. Al-Saman, T. A., & Wahab, R. J. (2012). Requirements for establishing total productive maintenance and its role in achieving competitive priorities: An applied study in Hammam Al-Alil Cement Plant Mosul. Rafidain Development Journal, 34(109), 28-96.
7. Boca, G. D. (2015). 5 S In Quality Management. North Center University of Baia Mare.
8. Chikwendu, O. C., Obiuto, C. N., & Ezeanyim, O. (2020). Agile Manufacturing System: Benefits, Challengers, and Critical Success Factor. Journal of Multidisciplinary Engineering Science and Technology (JMEST), 7(5).
9. Daft, R. (2010). Management (9E). Newyork.
10. Dischler, V., & Hug, A. (2011). The Relevancy of Agile Manufacturing in small and Medium Enterprises (Master Thesis). Linkoping University Department of Management and Engineering in International Organizations.
11. Durbin, S. (2012). Knowledge workers, careers&Networks: A case Study of Senior Female Scientists Auk Public Sector Organization, 18(1).
12. Hallgren, M., & Olhager, J. (2009). Lean and Agile Manufacturing: external and Internal Drivers and Performance Ontcomes. International Journal of Operations&Production Management, 29(10), 979.
13. Heizer, J., & Render, B. (2006). Principle of Operations Management (6th ed.). New Jersey.
14. John, C. (2009). Evaluating the Success of Total Productive Maintenance at Faurecia Interior Sys.
15. Jouda, M. A. (2004). Total quality management: Concepts and applications (1st ed.). Wael Publishing House.
16. Koh, L., & Wang, L. (2010). Enterprise networks and logistics for agile manufacturing. Springer London Dordrecht Heidelberg Newyork.
17. Krajewski, L. J., Ritzman, L. P., & Malhotra, M. (2010). Opertion Management Processes and Supply chains (9th ed.). Pearson Education.
18. Kumar, V., & Dev, C. (2015). International Journal of Technical Research and Applications –ISSN: 2320-8163, 1(12).
19. Sharma, R., & Singh, J. (2015). Impact of Implementing Japanese 5S Practices on Total Productive Maintenance. International Journal of Current Engineering and Technology, 5(2), 821.
20. Slack, N., Chanbers, S., & Johnston, R. (2004). Operations Management (4th ed.). Prentice Hall.