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*Article*

# The Relationship between Re-engineering Production Processes and Additive Manufacturing: A Case Study of the Iraqi Electrical Industries Company Using a Questionnaire-Based Approach

Khawlah Radhi Athab

*AL-Qadisiyah University College of Administration and Economics, Iraq*

**Abstract:** This study aims to examine the relationship between process reengineering and additive manufacturing at the Iraqi Electrical Industries Company, by analyzing the impact of reengineering dimensions (process definition, redesign, and change management) on the level of adoption of additive manufacturing. The study used a descriptive-analytical approach and relied on a questionnaire administered to a random sample of 183 employees from the production, engineering, maintenance, and quality departments. Data were analyzed using SPSS statistical software, using descriptive statistics, Pearson's correlation coefficients, and multiple linear regression. The results showed a strong and statistically significant correlation between the three dimensions and additive manufacturing, with redesign having the greatest impact, followed by process definition and change management. The study recommends adopting a comprehensive process reengineering plan that enhances the engagement of technical teams, intensifies training in digital manufacturing techniques, and supports institutional leadership in creating an environment conducive to change.

**Keywords:** Reengineering, Additive Manufacturing, Redesign, Change, Production Processes

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## 1. Introduction

Industrial companies need to overhaul their production procedures due to the quick industrial changes worldwide because of the Fourth Industrial Revolution requirements. The implementation of additive manufacturing stands as the foremost characteristic during this period. The manufacturing technique has changed conventional production patterns because it helps businesses create customized products and minimize waste and operate more efficiently (Rahito et al., 2019). Process reengineering efforts must be included in your strategic approach to achieve competitive advantage because they help maximize the benefits of this technology (Patrucco et al., 2020).

The present study has value because it conducts an applied case analysis at the Iraqi Electrical Industries Company to investigate process reengineering and additive manufacturing adoption connections. The research implements field data collection by distributing questionnaires to staff members from production and engineering departments to provide quantitative insights for science-based theoretical and statistical practice applications (Tripathi and Gupta, 2021). Through this study the literature receives additional value regarding how to integrate advanced technologies into

production development strategies specifically designed for emerging industrial conditions which implement smart flexible production systems to increase their market competitiveness.

Research problem

Although there has been technological development in the additive manufacturing and the opportunity it presents in order to save on costs, enhance quality, and provide more flexibility in production, there are still challenges in the seamless application of this new technology in the production process of many industrial organizations, including the Iraqi Electrical Industries Company. Such challenges are emphasized by the fact that there is no clear systematic plan of how reengineering could be applied to production processes, so that the institutional and technical infrastructure is in place to support the additive manufacturing demands. There are also difficulties in change management and defining the processes that should be redesigned and the willingness of the human resources and infrastructure to shift to digital production. Therefore, the issue of the research is based on the necessity to examine the connection between reengineering of the production processes and additive manufacturing, and to understand how well these engineering factors, including process definition, redesign, and change management, can help the change. Thus, the research question will be as follows:

What is the nature of the relationship between reengineering production processes and additive manufacturing at the Iraqi Electrical Industries Company?

Hypothesis

Main Hypothesis: There is no statistically significant relationship between process reengineering and additive manufacturing at the Iraqi Electrical Industries Company.

Sub-Hypotheses:

There is no statistically significant relationship between process identification and additive manufacturing at the Iraqi Electrical Industries Company.

There is no statistically significant relationship between process redesign and additive manufacturing at the Iraqi Electrical Industries Company.

There is no statistically significant relationship between change management and additive manufacturing at the Iraqi Electrical Industries Company.

Literature Review

Recent decades have witnessed growing interest in the scientific literature in the concept of reengineering production processes, particularly in light of the transformations imposed by the Fourth Industrial Revolution and the development of additive manufacturing technologies. Studies indicate that the integration of these two fields is a crucial factor in enhancing industrial performance and corporate competitiveness. Patrucco et al. demonstrated, through an applied study in the construction sector, that reengineering supply chains within an Industry 4.0 environment requires precise coordination in materials management, which also applies to the broader industrial environment [1]. The integration of smart data together with process engineering serves as a vital approach according to Khan et al to reach complete operational improvements [2]. According to Ghanem production line redesign that implements Industry 4.0 principles results in better quality output and waste minimization through complete production stage reengineering [3]. Rahito et al study focused on additive manufacturing applications for industrial maintenance and repair as they explained how these applications cut costs and double product operational lifespans [4]. Massaro and Galiano demonstrated the need for process reengineering together with digital manufacturing technologies in food manufacturing because they enhance industry efficiency [5]. The research conducted by Azman proves that additive manufacturing serves as both an enhancement tool for production efficiency and an operational support mechanism in circular economy remanufacturing [6]. The application of additive manufacturing techniques for automotive component redesign through IDeS methodology is explained through the work of Leon Cardenas [7], [8].

Tripathi and Gupta presented a purchasing process reengineering framework that integrates intelligence analytics technology into decision-making environments of Industry 4.0 [9]. Additive manufacturing with ecological principle-based redesign coupled with reverse engineering helps the industrial sector adopt circular economy practices as per Vacchi et al. [10]. Salem et al. investigated design frameworks for additive manufacturing which serve as critical elements for product redesign programs resulting in faster product development times [11]. Kahhal et al. assessed modern advancements in industrial remanufacturing processes and surface treatment methods which enhance end-product quality [12]. The work of Frey et al provided an extensive evaluation of ontology systems linking to additive manufacturing before concluding on its essential purpose for fast emergency response through industrial process modeling [13].

The combination of process reengineering and efficient additive manufacturing implementation demonstrates strategic importance because they necessitate extensive analysis of production systems combined with institutional restructuring within Iraqi industry.

Spatial and temporal limits

The spatial boundaries of this research were defined by the Iraqi Electrical Industries Company, as it represents a local industrial model facing real challenges in the field of developing production processes and adopting additive manufacturing technologies, making it an appropriate environment for analyzing the relationship between the two concepts under study. In terms of temporal boundaries, this research was conducted during the period extending from the first month (January) to the third month (March) of the year 2025. During this period, the research tool was designed, questionnaires were distributed, and data was collected from employees in the production, engineering, maintenance, and quality departments. The data was then analyzed using appropriate statistical methods to arrive at the desired results.

## 2. Materials and Methods

This research relied on the descriptive-analytical approach, as it is the most appropriate for studying the relationship between two variables and interpreting administrative and production phenomena through field data. This approach is based on describing reality as it is, analyzing the relationships between its components, and extracting statistically significant indicators. The research tool was constructed in the form of a closed questionnaire that included a set of items distributed across the main axes representing the dimensions of reengineering production processes (process definition, redesign, change management), in addition to the additive manufacturing axis. The sample's responses were measured using a five-point Likert scale.

The research started with a step of establishing the theoretical framework by studying current literature that focused on the study topic. Following step one, researchers built their measurement tool which was then given to sample members before data transformation for statistical analysis. All measurement tool axes displayed high reliability values in Cronbach's alpha coefficient tests affirming the instrument's reliability. The data suitability for confirmatory factor analysis verification relied on both KMO test results and Pearson's correlation coefficient measurements. Statistical procedures implemented during analysis included several methods:

1. Descriptive statistics (arithmetic means, standard deviations, percentages) to determine the level of sample responses.
2. Pearson's t-test to measure the strength of the relationship between variables.
3. Multiple linear regression analysis to measure the impact of process reengineering dimensions on additive manufacturing.
4. Tests to verify statistical modeling conditions, such as the Shapiro-Wilk test to measure the normal distribution of residuals, the Durbin-Watson test to detect autocorrelation, the Brioche-Beggan test to test for homogeneity of variance, and the Variance Factor Analysis (VIF) to detect multicollinearity.

All analyses were performed using SPSS version 29, which provided a reliable statistical environment for analyzing data and drawing accurate and objective conclusions.

Population and sample

Employees from all departments that participate in production at the Iraqi Electrical Industries Company formed the study population. This includes personnel from the production, engineering, maintenance and quality control departments. The researcher selected this population because it directly links to the research field which guarantees reliable and genuine findings. The Slovin equation provided the sample size determination for this known population because it helps researchers find the right sample quantity when they understand population numbers exactly. The researchers implemented a 95% confidence standard equating to 5% error margin. The company estimated a target group of 350 employees which led to the requirement of a representative sample of 183 people according to the calculated equation:

$$n = \frac{N}{1 + N(e^2)}$$

n = Required sample size, N = Total population size, e = Margin of error (typically set at 5% or 0.05 for a 95% confidence level).

$$n = \frac{350}{1 + 350(0.05^2)} = 175.7$$

To ensure adequate coverage and avoid exclusion or non-response, 188 questionnaires were distributed, and 183 completed questionnaires were returned, valid for statistical analysis. This represents a response rate of approximately 97.3%, which is acceptable and enhances the accuracy of the study results. The sample was selected using a simple random method to ensure fair representation of all relevant segments and to reduce bias in the data.

The theoretical concept of the research

This investigation utilizes process reengineering and additive manufacturing as its theoretical basis because industrial organizations want to use these modern concepts to boost efficiency and competitiveness. Process reengineering represents a method which involves fundamental evaluation and redesign of operational processes to produce major performance improvements for both quality and cost and speed and flexibility levels [1]. As a strategic organizational instrument organizations use this process to transform traditional work systems by focusing on three essential dimensions which include process identification together with redesign elements and also change management functions. Organizations capable of analyzing existing procedures to detect system shortcomings make up the process identification dimension [5]while the redesign dimension describes an organization's power to create innovative solutions transforming operational processes for present-day purposes [14]. Individuals and the administrative system show their preparedness for organizational transformations which reengineering creates through the change management dimension [15]. The industrial technology of additive manufacturing develops products through successive additions depending on 3D printing or equivalent processes. The method marks a complete reconstruction of how manufacturers approach industrial component design and production processes. The technology stands out for its three key benefits which include waste reduction and demand-specific product customization and shortened development timelines [4]. Organizations achieve increased value from their operations through additive manufacturing when they successfully implement it within their manufacturing systems combined with redesigned production systems that establish technical and organizational frameworks [6], [12].

The literature promotes these concepts as closely interlinked since additive manufacturing technologies reach their highest potential only with process-based organizational and technical changes that mandate reengineering procedures. Organizations that excel at adaptability and transformation management will find it easier to implement and capitalize from digital manufacturing according to Vacchi et al. [7], [10]. This relationship establishes why the current investigation matters since it will measure additive manufacturing impacts under realistic industrial circumstances at the Iraqi Electrical Industries Company.

## 3. Results

Study tool

The study tool consisted of a carefully designed questionnaire to collect data related to the research topic, which addressed the relationship between process reengineering and additive manufacturing at the Iraqi Electrical Industries Company. There were three sections of the questionnaire. The former part started with the demographics of the participants in the study, which sought to explain the characteristics of the sample and get an insight into the diversity of the sample in terms of gender, age bracket, the level of education, the years of experience working in the company, or the job department where the respondents worked. This part contained closed-ended questions whereby the respondent could pick the best answer that was pre-determined.

The second part was allocating to the measurement of the independent variable of the study, which is process reengineering. It was categorized into three major dimensions:

The first dimension is Process Definition, which implies five items that gauge clarity and comprehensibility of the production procedures in the organization, graphic analysis as a means of bottleneck identification, and the involvement of the employees in coming up with the improvements. The second dimension, Redesign, will comprise five items that gauge the degree of the trend of technological modernization, the attainment of flexibility, the use of multidisciplinary teams, and the implementation of innovation in order to optimize the operations. The third dimension, Change Management, consists of five items that consist of measuring institutional communication mechanisms in implementing change, offering the required training, resistance to change, the leadership role in guiding the process, and the degree of implementation of an organized change plan.

The third section is a measure of the dependent variable, Additive Manufacturing, which is measured in eight items that understand how the technology is adopted by the company, how much it can be regarded as a strategic investment, the effect that it has on the personalization of products, waste reduction, and efficiency, employee training, shorter development time, and the degree to which it is committed to further use of the technology. The questions in the second and third parts were constructed with the five point Likert scale to indicate the level of agreement, and a response of (1) means Strongly Disagree, (5) Strongly Agree. The instrument was formulated in such a way that it covered the dimensions of the two concepts under study. It was also reviewed academically to warrant its appropriateness to the purpose of the research before being given to the sample of the study and analyzed through the use of the SPSS statistical program.

Validity and reliability of the questionnaire

**Table 1.** Cronbach's Alpha Coefficients for the Questionnaire Variables and Dimensions

| Variable / Dimension | Number of Items | Cronbach's Alpha |
|---|---|---|
| Process Identification | 5 | 0.88 |
| Process Redesign | 5 | 0.91 |
| Change Management | 5 | 0.89 |
| Re-engineering Production Processes (Overall) | 15 | 0.93 |
| Additive Manufacturing | 8 | 0.90 |
| Entire Questionnaire | 23 | 0.94 |

Source: Prepared by the researcher based on sample data and SPSS29 program.

Depending on the results of the Cronbach's alpha coefficient, it is possible to say that the questionnaire has a high level of internal reliability as well as internal consistency. The dimensions were all above the acceptable level of 0.70 that is considered statistically acceptable and the total value was 0.94, which indicates a high level of reliability in the measurement of variables. The three dimensions of process reengineering also exhibited high levels of reliability (between 0.88 and 0.91) and the additive manufacturing dimension had a value of 0.90 which increased the reliability of the results of the tool to be used to make the analysis and conclusions. This indicates that the items used in the questionnaire are internally related and effectively measure the concepts that are targeted.

**Table 2.** KMO and Bartlett's Test Results for the Questionnaire Variables and Dimensions

| Variable / Dimension | KMO Measure | Bartlett's Test Approx. Chi-Square | Sig. (p-value) |
|---|---|---|---|
| Process Identification | 0.84 | 172.623 | 0.000 |
| Process Redesign | 0.88 | 194.371 | 0.000 |
| Change Management | 0.85 | 183.754 | 0.000 |
| Re-engineering Production Processes (Overall) | 0.90 | 658.218 | 0.000 |
| Additive Manufacturing | 0.86 | 412.587 | 0.000 |
| Entire Questionnaire | 0.91 | 1325.489 | 0.000 |

Source: Prepared by the researcher based on sample data and SPSS29 program

Data gathered via the Kaiser-Meyer-Olkin (KMO) test revealed strong uniformity among questionnaire items across all dimensions as their values fell within 0.84 to 0.91 indicating the items work consistently inside each study subsection. All variables demonstrated significant interconnection in questionnaire items per the Bartlett test results which reached statistical significance at $p = 0.000$.

**Table 3.** Pearson Correlation Coefficients Between Dimensions, Variables, and the Total Questionnaire Score

| Variable / Dimension | Correlation with Total Score (r) |
|---|---|
| Process Identification | 0.71 |
| Process Redesign | 0.76 |
| Change Management | 0.74 |
| Re-engineering Production Processes (Overall) | 0.83 |
| Additive Manufacturing | 0.79 |

Source: Prepared by the researcher based on sample data and SPSS29 program

The results of the Pearson correlation coefficients indicate a strong correlation between each of the study dimensions and the total score of the questionnaire. The correlation value between the "Process Defining" dimension and the total score was (0.71), between "Redesign" (0.76), and "Change Management" (0.74), while the reengineering of production processes as a whole recorded a correlation of (0.83). The correlation of the additive manufacturing dimension with the total score was (0.79). These values reflect the strong consistency between the dimensions and the content of the tool, confirming the quality of the questionnaire design and its comprehensiveness in representing the targeted variables.

Demographic information analysis

**Table 5.** Demographic Characteristics of the Study Sample (N = 183)

| Variable | Category | Frequency (n) | Percentage (%) |
|---|---|---|---|
| **Gender** | Male | 132 | 72.1% |
| | Female | 51 | 27.9% |
| **Age Group** | 20–30 years | 39 | 21.3% |
| | 31–40 years | 62 | 33.9% |
| | 41–50 years | 47 | 25.7% |
| | Above 50 | 35 | 19.1% |
| **Educational Level** | Diploma | 22 | 12.0% |
| | Bachelor's Degree | 108 | 59.0% |
| | Master's Degree | 41 | 22.4% |
| | Ph.D. | 12 | 6.6% |
| **Work Experience** | Less than 5 years | 29 | 15.8% |
| | 5–10 years | 74 | 40.4% |

| Variable | Category | Frequency (n) | Percentage (%) |
|---|---|---|---|
| | More than 10 years | 80 | 43.7% |
| **Department** | Production | 69 | 37.7% |
| | Engineering | 38 | 20.8% |
| | Quality Control | 41 | 22.4% |
| | Maintenance | 35 | 19.1% |

Source: Prepared by the researcher based on sample data and SPSS29 programmer

Demographic data for the study sample of 183 participants showed that the majority of respondents were male (72.1%), compared to 27.9% female, reflecting the masculine nature of the industrial work environment. The sample was relatively evenly distributed across age groups, with the largest group being those aged 31 to 40 years old (33.9%), followed by those aged 41 to 50 years old (25.7%), those aged 20 to 30 years old (21.3%), and those over 50 years old (19.1%). In terms of educational level, the largest percentage (59%) held a bachelor's degree, followed by a master's degree (22.4%), a diploma (12%), and a doctorate (6.6%). Regarding job experience, 43.7% of participants had more than 10 years of experience, the majority, followed by 40.4% with 5–10 years, and 15.8% with less than 5 years. In terms of departmental distribution, the production department led the way with 37.7%, followed by the quality department with 22.4%, engineering with 20.8%, and finally, maintenance with 19.1%. These results reflect the diversity of the sample and its coverage of all departments and characteristics relevant to the study topic. The graph illustrates the distribution:

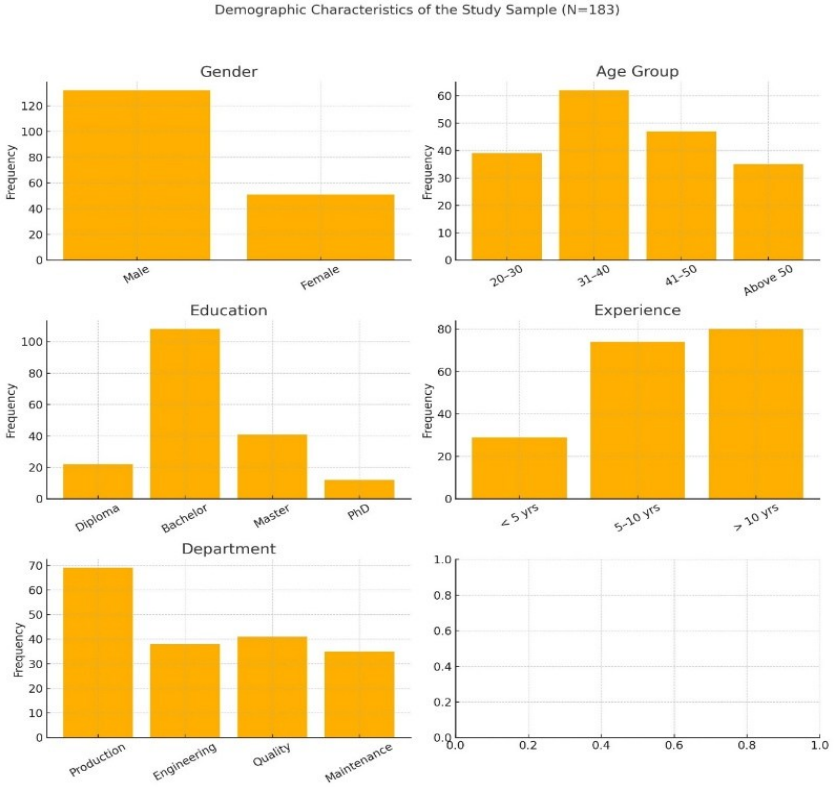



**Figure 1.** Demographic Distribution
**Source:** Prepared by the researcher based on sample data and SPSS29 program

Descriptive Statistics and Graphical Analysis:
It includes analysis and classification of answers according to the following table:

**Table 6.** Classification of Relative Importance and Likert Scale Result

| Mean Range | Likert Scale Result | Relative Importance |
|---|---|---|
| 1.00 – 1.80 | Strongly Disagree | Very Low |
| 1.81 – 2.60 | Disagree | Low |

| Mean Range | Likert Scale Result | Relative Importance |
|---|---|---|
| 2.61 – 3.40 | Neutral | Moderate |
| 3.41 – 4.20 | Agree | High |
| 4.21 – 5.00 | Strongly Agree | Very High |

**Source:** Prepared by the researcher based on sample data and SPSS29 program

**Table 7.** Descriptive Statistics – Process Identification

| Statement | Mean | Std. Dev. | Relative Importance (%) | Result (Likert Scale) |
|---|---|---|---|---|
| The current production processes are clearly documented and well understood. | 3.9 | 0.6 | 78.0 | High |
| The company regularly evaluates its production workflows to identify inefficiencies. | 4.2 | 0.5 | 84.0 | High |
| Employees are involved in identifying areas for process improvement. | 3.7 | 0.7 | 74.0 | Moderate |
| The company uses data analysis to identify bottlenecks in production. | 4.1 | 0.6 | 82.0 | High |
| There is a systematic approach to process mapping and assessment. | 3.8 | 0.7 | 76.0 | Moderate |
| **Process Identification (Overall)** | 3.94 | 0.62 | 78.8 | High |

**Source:** Prepared by the researcher based on sample data and SPSS29 program

The findings of the descriptive analysis of the Process Defining dimension reveal that the total arithmetic mean of the dimension was (3.94) and the standard deviation of (0.62), which revealed a high degree of awareness that the participants had to the aspect of the dimension in the work environment. The top rated items in this dimension were: "Regularly evaluate workflow" (84.0%), and "Using graphic analysis to identify bottlenecks" (82.0%), both of which are positive corporate practices in monitoring and efficiency of processes. Conversely, the questions like Employee Participation in Improvement, Following a Methodology to Map Processes, had moderate level of agreement of (74.0) and (76.0), respectively. These findings demonstrate a definite tendency in the company toward the documentation and assessment, and the necessity to raise the level of employee involvement and introduce systematic approaches to the studies of the procedures.

**Table 8.** Descriptive Statistics – Process Redesign

| Statement | Mean | Std. Dev. | Relative Importance (%) | Result (Likert Scale) |
|---|---|---|---|---|
| The company redesigns production processes to align with technological advancements. | 4.0 | 0.5 | 80.0 | High |

| Statement | Mean | Std. Dev. | Relative Importance (%) | Result (Likert Scale) |
|---|---|---|---|---|
| Process changes aim to improve flexibility and reduce cycle time. | 4.3 | 0.4 | 86.0 | High |
| Cross-functional teams are engaged in process redesign activities. | 3.6 | 0.6 | 72.0 | Moderate |
| The organization adopts innovative approaches in process improvement. | 4.1 | 0.6 | 82.0 | High |
| Redesign efforts focus on integrating digital manufacturing tools. | 3.9 | 0.5 | 78.0 | High |
| **Process Redesign (Overall)** | 3.98 | 0.52 | 79.6 | High |

**Source:** Prepared by the researcher based on sample data and SPSS29 program

The results of the descriptive analysis of the "Process Redesign" dimension showed that the overall arithmetic mean was (3.98) with a standard deviation of (0.52), indicating a high level of orientation towards developing the company's production processes. The item "Focusing on improving flexibility and reducing cycle time" achieved the highest importance rate of (86.0%), followed by the item "Adopting innovative methods" with (82.0%), reflecting a clear orientation towards innovation and technological modernization. Most items were at a high level, with the exception of the item "Involving multidisciplinary teams", which scored (72.0%), which is at an average level, indicating that the involvement of these teams is still below the required level. These results reflect a good institutional readiness to adopt redesigned processes, especially with regard to technology and innovation, with a need to enhance collaborative work between departments.

**Table 9.** Descriptive Statistics – Change Management

| Statement | Mean | Std. Dev. | Relative Importance (%) | Result (Likert Scale) |
|---|---|---|---|---|
| The company communicates process changes effectively to employees. | 3.8 | 0.7 | 76.0 | Moderate |
| Training is provided to support new production methods. | 4.0 | 0.6 | 80.0 | High |
| Resistance to change is managed proactively. | 3.5 | 0.8 | 70.0 | Moderate |
| Leadership supports and guides the change process. | 4.2 | 0.5 | 84.0 | High |
| A structured change management plan is implemented during re-engineering efforts. | 3.7 | 0.7 | 74.0 | Moderate |
| **Change Management (Overall)** | 3.84 | 0.66 | 76.8 | High |

**Source:** Prepared by the researcher based on sample data and SPSS29 program

The results of the descriptive analysis of the "Change Management" dimension indicate that the overall arithmetic mean was (3.84) with a standard deviation of (0.66), reflecting a relatively high level of employee awareness of change management practices within the company. The item "Leadership support for the change process" received the highest importance at (84.0%), followed by "Providing training to support new production methods" at (80.0%), indicating clear institutional support for the

organizational and educational aspects of change. In contrast, items such as "Managing resistance to change" and "Organized change plan" recorded lower percentages, ranging between (70.0%) and (74.0%), indicating gaps in the systematic handling of change challenges. The results reflect that the work environment possesses good elements to support change, but it needs more focus on implementation aspects to ensure the sustainability of effective transformation.

**Table 10.** Descriptive Statistics – Additive Manufacturing

| Statement | Mean | Std. Dev. | Relative Importance (%) | Result (Likert Scale) |
|---|---|---|---|---|
| The company utilizes additive manufacturing in selected production activities. | 3.7 | 0.6 | 74.0 | Moderate |
| Additive manufacturing is viewed as a strategic investment in the company. | 4.1 | 0.5 | 82.0 | High |
| The adoption of additive manufacturing has improved product customization. | 3.9 | 0.6 | 78.0 | High |
| Additive manufacturing contributes to reducing material waste. | 3.6 | 0.7 | 72.0 | Moderate |
| Employees are trained in additive manufacturing technologies. | 4.0 | 0.5 | 80.0 | High |
| The integration of additive manufacturing has enhanced production efficiency. | 3.8 | 0.6 | 76.0 | High |
| Additive manufacturing has led to a reduction in lead time for product development. | 3.5 | 0.8 | 70.0 | Moderate |
| The company is committed to expanding the use of additive manufacturing in the future. | 4.2 | 0.4 | 84.0 | High |
| **Additive Manufacturing (Overall)** | 3.85 | 0.59 | 77.0 | High |

**Source:** Prepared by the researcher based on sample data and SPSS29 program

The outcome of the descriptive analysis of the "Additive Manufacturing" revealed that the arithmetic mean was (3.85) with the standard deviation (0.59), which means that the degree of commitment to adopting this technology in the company is considerable. The highest importance rate was (84.0%), in the item, mission commitment to increasing the utilization of additive manufacturing in the future, then the item, consider additive manufacturing as a strategic investment, (82.0%), which is the clarity of the corporate vision concerning the use of this technology. Also with high importance were items that belong to the category of improving customization, increasing efficiency, and training employees, and the range of their importance was (76.0) to (80.0). Conversely, such items like Reducing development time and Reducing waste were on the intermediate as they were at (70.0%) and (72.0%), respectively, and it shows that not all practical implications of the technology have been fully realized. The findings are mostly indicative of the presence of an institutional framework that underpins additive manufacturing, and the necessity to increase its efficacy as an operation with the wider usage and practical application.

Hypothesis testing

**Table 11.** Pearson Correlation Coefficients Between Independent Variables and Additive Manufacturing

| Independent Variable / Dimension | Correlation with Additive Manufacturing (r) | Sig. (p-value) |
|---|---|---|
| Process Identification | 0.78 | 0.000 |
| Process Redesign | 0.81 | 0.000 |
| Change Management | 0.75 | 0.000 |
| Re-engineering Production Processes (Overall) | 0.93 | 0.000 |

**Source:** Prepared by the researcher based on sample data and SPSS29 program

Pearson's correlation coefficients indicate strong and statistically significant correlations between the dimensions of process reengineering and additive manufacturing. The correlation between "process definition" and additive manufacturing reached 0.78, between "redesign" (0.81), and between "change management" (0.75), all at the 0.000 level, reflecting strong significance. The overall variable "process reengineering" recorded the highest correlation with additive manufacturing (0.93), confirming that the integration of these dimensions is a crucial factor in supporting the adoption of additive manufacturing within the industrial workplace.

**Table 12.** Multiple Linear Regression Results for the Effect of Re-engineering Dimensions on Additive Manufacturing

| R | $R^2$ (Coefficient of Determination) | Adjusted $R^2$ | | Std. Error of Estimate |
|---|---|---|---|---|
| 0.94 | 0.88 | 0.88 | | 0.276 |
| **Source** | **F-value** | **Sig. (p-value)** | | |
| Regression | 431.27 | 0.000 | | |
| **Variable** | **Unstandardized Coefficient (B)** | **Std. Error** | **t-Statistic** | **Sig. (p-value)** |
| Process Identification | 0.215 | 0.058 | 3.71 | 0.000 |
| Process Redesign | 0.294 | 0.064 | 4.59 | 0.000 |
| Change Management | 0.187 | 0.061 | 3.07 | 0.002 |
| **Constant** | 1.122 | 0.313 | 3.58 | 0.001 |

**Source:** Prepared by the researcher based on sample data and SPSS29 program

The results of the multiple linear regression analysis showed that the study model explained a significant proportion of the variance in the additive manufacturing variable. The coefficient of determination ($R^2$) was 0.88, indicating that 88% of the variation in the level of additive manufacturing adoption can be explained by the dimensions of reengineering production processes. The R value (0.94) also indicated the strength of the relationship, and the F value (431.27) at the significance level (0.000), confirming the significance of the statistical model. At the level of the independent variables, it was found that all three dimensions had a statistically significant impact on additive manufacturing. The unstandardized impact factor for the "Process Defining" dimension was (0.215) with a value (t = 3.71) and a significance of (0.000), while the "Redesign" dimension had the highest impact (0.294) with a value (t = 4.59) and a significance of (0.000). The "Change Management" dimension recorded (0.187) with a value (t = 3.07) and a significance of (0.002). The constant in the model was (1.122), which indicates the initial value of additive manufacturing if all independent

variables were held constant. These results confirm the positive and combined impact of reengineering dimensions in supporting the implementation of additive manufacturing in the company.

**Table 13.** Regression Model Diagnostics Summary

| Diagnostic Aspect | Test Used | Test Statistic / Value | Threshold / Criterion | Interpretation |
|---|---|---|---|---|
| **Normality of Residuals** | Shapiro–Wilk Test | W = 0.981, **p = 0.068** | p > 0.05 | Residuals are normally distributed |
| **Autocorrelation of Residuals** | Durbin–Watson Test | DW = 1.91 | Between 1.5 and 2.5 | No autocorrelation detected |
| **Homoscedasticity of Residuals** | Breusch–Pagan Test | $\chi^2$ = 3.21, **p = 0.217** | p > 0.05 | Homoscedasticity confirmed |
| **Multicollinearity** | Variance Inflation Factor (VIF) | | | |
| Process Identification = 1.42<br>Process Redesign = 1.63<br>Change Management = 1.39 | VIF < 5 | No multicollinearity | | |
| **Outliers / Influence** | Cook's Distance | Max Cook's D = 0.07 | < 1 | No influential outliers |

**Source:** Prepared by the researcher based on sample data and SPSS29 program

The results of the regression model diagnostic tests indicate that the model meets the requirements for statistical analysis, enhancing the reliability of its results. The Shapiro-Wilk test showed that the model's residuals followed a normal distribution (W = 0.981, p = 0.068), while the Durbin-Watson test (DW = 1.91) indicated the absence of autocorrelation among the residuals. The Brioche-Beggan test confirmed homogeneity of variance (p = 0.217), indicating the stability of the variance of the errors. Furthermore, the VIF values for all variables were less than 5, indicating the absence of multicollinearity among the independent variables. Cook's Distance analysis showed that the maximum value did not exceed 0.07, which is less than the permissible limit (<1), confirming the absence of influential extreme values in the model. These results confirm that the statistical model is stable and valid for interpretation and analysis. The following figure illustrates the quality of the residuals:

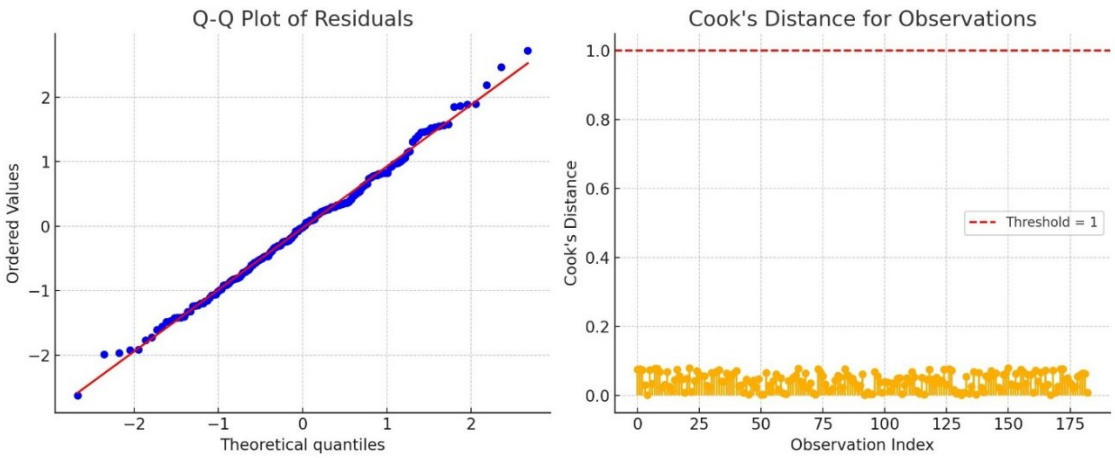



**Figure 2.** Diagnostic for residuals
**Source:** Prepared by the researcher based on sample data and SPSS29 program

## 4. Discussion

The findings demonstrate that re-engineering production processes plays an important role in facilitating the adoption of additive manufacturing at the Iraqi Electrical Industries Company. From an organizational perspective, this relationship suggests that additive manufacturing should not be regarded merely as the introduction of new production equipment or digital technology, but rather as part of a broader transformation of existing production systems. Successful implementation therefore requires organizations to identify inefficient activities, reconsider established workflows, and align technological capabilities with redesigned operational procedures. This interpretation is consistent with Patrucco et al. [1], who emphasized that the implementation of Industry 4.0 technologies requires the reconfiguration and coordination of existing processes rather than isolated technological interventions. Similarly, Tripathi and Gupta [14] highlighted the importance of process re-engineering in creating organizational structures capable of supporting technology-driven decision-making and operational transformation.

Among the dimensions examined, process redesign emerged as the most influential element in supporting additive manufacturing. This finding can be explained by the characteristics of additive manufacturing itself, which often require substantial changes in product design, production sequencing, resource utilization, and interactions between engineering and manufacturing activities. Traditional production procedures may therefore limit the potential benefits of additive manufacturing when they are retained without appropriate modification. The present finding is consistent with Rahito et al. [4], who demonstrated that additive manufacturing can significantly contribute to repair and remanufacturing activities when product and production systems are appropriately redesigned. It is also in line with Kahhal et al. [12], who indicated that the effectiveness of additive manufacturing technologies in remanufacturing depends on their integration with suitable production and surface-treatment processes. Thus, the strong role of redesign observed in the present study indicates that technological adoption becomes more effective when the organization simultaneously restructures the processes within which the technology is applied.

Process identification also represents an important foundation for additive manufacturing implementation. Clear documentation, systematic process mapping, and the identification of production bottlenecks enable organizations to determine where additive manufacturing can generate the greatest operational value. The relatively positive perception of workflow evaluation and data-based identification of production constraints therefore reflects an important organizational capability within the company. However, the comparatively lower employee participation in process improvement indicates that process identification remains predominantly procedural rather than fully participatory. This issue is important because re-engineering depends not only on technical analysis but also on knowledge obtained from employees directly involved in

production activities. Massaro and Galiano [5] similarly emphasized that digital manufacturing transformation requires an integrated approach in which technological improvements are connected with the redesign and analysis of existing production processes. Moreover, data-driven process re-engineering has been identified as an important mechanism for improving manufacturing optimization and understanding process interdependence [15].

The findings concerning change management further indicate that leadership support and employee training provide a relatively strong foundation for organizational transformation, while resistance management, structured implementation, and communication still require greater attention. This pattern suggests that managerial commitment alone may not be sufficient to ensure the sustainable adoption of additive manufacturing unless it is translated into systematic change-management mechanisms. Employees must understand not only how to operate new technologies but also why processes are being changed and how their roles will be affected. The importance of this organizational dimension is particularly relevant because additive manufacturing may alter established responsibilities, technical competencies, coordination mechanisms, and decision-making processes. Consequently, resistance to change may emerge when technological transformation proceeds more rapidly than organizational adaptation.

The results related to additive manufacturing also suggest that the company possesses a positive strategic orientation toward expanding the technology, although some of its expected operational benefits have not yet been fully realized. In particular, the stronger perception of additive manufacturing as a strategic investment and the company's commitment to its future expansion indicate institutional willingness to continue technological modernization. At the same time, the more moderate achievements related to waste reduction and shorter product-development lead times suggest that the organization may still be in a transitional stage of adoption. This interpretation is consistent with Vacchi et al. [10], who argued that the benefits of advanced manufacturing technologies for circular production and resource efficiency depend on their integration with product and process re-engineering. Likewise, Rahito et al. [4] and Azman [6] showed that additive manufacturing can contribute to material efficiency and remanufacturing performance when it is effectively embedded within the overall production system.

Taken together, the findings indicate that the relationship between process re-engineering and additive manufacturing is both technological and organizational. Additive manufacturing appears to generate greater value when process identification, process redesign, and change management operate as mutually reinforcing capabilities rather than as separate initiatives. The particularly important role of process redesign suggests that the Iraqi Electrical Industries Company should prioritize the restructuring of production workflows, strengthen cross-functional collaboration among production, engineering, maintenance, and quality departments, and integrate digital manufacturing tools into redesigned processes. At the same time, greater employee participation and more structured management of resistance to change would help ensure that technological modernization is accepted and sustained throughout the organization. These findings reinforce the view that successful industrial transformation requires the simultaneous development of technological infrastructure, process architecture, and organizational readiness rather than reliance on technology adoption alone.

## 5. Conclusion

The Iraqi Electrical Industries Company demonstrated through study results that process reengineering dimensions produced a positive relationship with additive manufacturing adoption. The combined elements of process definition and redesign and change management provided major explanations of the variance in additive manufacturing adoption according to regression and correlation tests. Employees understand process reengineering serves as an essential strategic instrument for industrial performance improvement but documentation practices show higher implementation variations compared to participation and change management implementation

levels. The "redesign" dimension proves to be most important for implementing additive manufacturing yet "process definition" comes after then "change management." Integration with modern manufacturing technologies depends heavily on technical and technological elements according to this evidence. The findings of this analysis support the creation of thorough institutional process reengineering designs compatible with additive manufacturing standards through team collaboration and expert training sessions in digital manufacturing systems. Good leadership support combined with an innovative work environment promotes continuous enhancement and breakthrough innovation throughout the organization.

Research calls for a simultaneous management approach between administrative functions and technical implementations to maintain industrial transformation sustainability as it recommends conducting additional practical research in similar industrial sectors to boost relevant knowledge.

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