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# The Impact of the Fractal Manufacturing System on Product Quality through the Intermediary Role of Production Technology: an Analytical Study at the Public Company for Electrical and Electronic Industries – Baghdad

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The current research aims to clarify the effect of the segmented manufacturing system on the quality of products through the intermediate role of production technology in the Public Company for Electrical and Electronic Industries – Baghdad. The questionnaire was used as a research tool, and 200 questionnaires were distributed to the members of the company's board of directors, as well as factory managers and their assistants, managers of production lines, and engineers (production, design, electricity, electron and mechanical). The number of questionnaires retrieved totalled 174, meaning that the response rate was 87%. After examining the retrieved questionnaires, it was found that 169 questionnaires were valid for analysis. Shapiro-Wilk, Kolmogrov - Smirnov tests were used to perform the normal distribution test and for the purpose of conducting stability. The reliability test tools used in the research was based on the Cronbach Alpha test, as well as the statistical programs SPSS vr.24, and AMOS v.23 to analyse the data and extract the results. On this basis, a number of conclusions were reached, including the strong impact relationship between the fractal manufacturing system and product quality through production technology. This suggests that the research community has given sufficient attention to the development of production technology, and has played an effective role in promoting this relationship.

**Key words:** *Fractal manufacturing system, Production technology, Products quality.*

## Introduction

Because of the intense competition in the business environment today, organizations must pay great attention to the systems and methods that would provide sufficient flexibility to accommodate changes that are commensurate with developments in industry worldwide. One of these efficient methods and systems is the Fractal Manufacturing System that initially emerged as a way of reducing the complexity of the organizations as a result of the application of systems intelligent manufacturing, which required high-resolution information, successful management of a large number of units, and continued successful development Providing an integrated framework for the organization's manufacturing system will maximize efficiency and add value to manufactured products. The concept of the Fractal manufacturing system emerged from the World (Warnecke, 1993), when he indicated that each unit of the manufacturing system could be considered Fractal, and that each part of the plant operated independently and had its own objectives. In the same vein, Tharumarajah (1996: 217) indicates that an industrial organization is fragmented when it consists of small components or fragmented entities. A fractal entity can be defined as anything with a high degree of subjective or statistical similarity, and with individual parts that are similar to the whole system (Attar & Kulkami , 2014:1814). Sharif *et al.* (2013 : 44) similarly sees it as a highly flexible and highly versatile manufacturing system through the dynamic restructuring process, which is the most discriminating aspect of this system, as well as being easily adaptable to the dynamic environment. It is also intelligent, independent system and distributor to the independent function of the modules.

With regard to production technology, it is of great importance at the level of industrial business organizations, especially as it is one of the most important operational strategy decisions that contribute effectively to achieving the competitive priorities of the organization, as well as the many technological developments that have helped organizations rationalize their product designs by improving their quality and features that are characterized by characteristics and specifications. This is so that it is meets the needs and desires of customers on the one hand, and supports achieving the goals of the organization in increasing its market share on the other hand. Production technology is defined as equipment, personnel, and procedures used to manufacture products. The choice of technology affects every aspect of the production process: the level of personnel skills, training, equipment, location, organization characteristics, operating metrics, and even operational issues such as machinery requirements, scheduling, tools, maintenance, and the ways in which technologies are used are important strategic issues (Martinich , 1997 :47). Krajweski *et al.* (2016 : 148) referred to this as the methods used by any organization to accomplish things (products and services), which are dependent on the production process. As for the product quality, it means performing things correctly, and meausring the quality of the good or service as it is perceived by the customer. Operations management endeavours to provide quality goods and services that conform with specifications to achieve customer satisfaction, which represents the most important part of the production plan. The quality goal must be the present and future needs of the customer.

## Research Methodology

### *Research Problem*

Manufacturing systems today need to adapt to the accelerating environmental changes that reflect the change in customer demand, continuous technological developments, advanced infrastructure and other matters that require industrial organizations to respond quickly to these changes by adopting advanced systems and methods as well as enjoying a high degree of flexibility in all of its activities, and to enable it to adapt according to these circumstances in a timely manner. The fractal manufacturing system is one of these systems that has the ability to adapt to the changes taking place, as it is a system that accepts error and deals with it precisely because it is self-reconfigurable and works under a fragmented architecture. The organization also relies on advanced technology in production, including methods, rules, devices, machines, and equipment used in the manufacturing processes of the products, for this contributes in a large way to raising product quality to the level that the company aspires to reach and ensuring customer satisfaction. Based on the above, the study problem can be presented as the following question: What is the effect of the fractal manufacturing system on the quality of products manufactured by the respondent organization with the existence of production technology as an intermediate variable?

### *Research Significance*

1- The importance of the research lies in the importance of the variables it presented and the positive effects it achieves through its work in supporting the goals of the organization it seeks to reach in the area of raising the level of the product quality it provides and increasing its market share.
2- Directing the attention of senior management in industrial organizations to pay attention to production technology because of its great role in the success of the organization's work in achieving competitive advantages as well as providing the appropriate ground for the application of modern manufacturing systems, including the fractal manufacturing system.

### *Research Objectives*

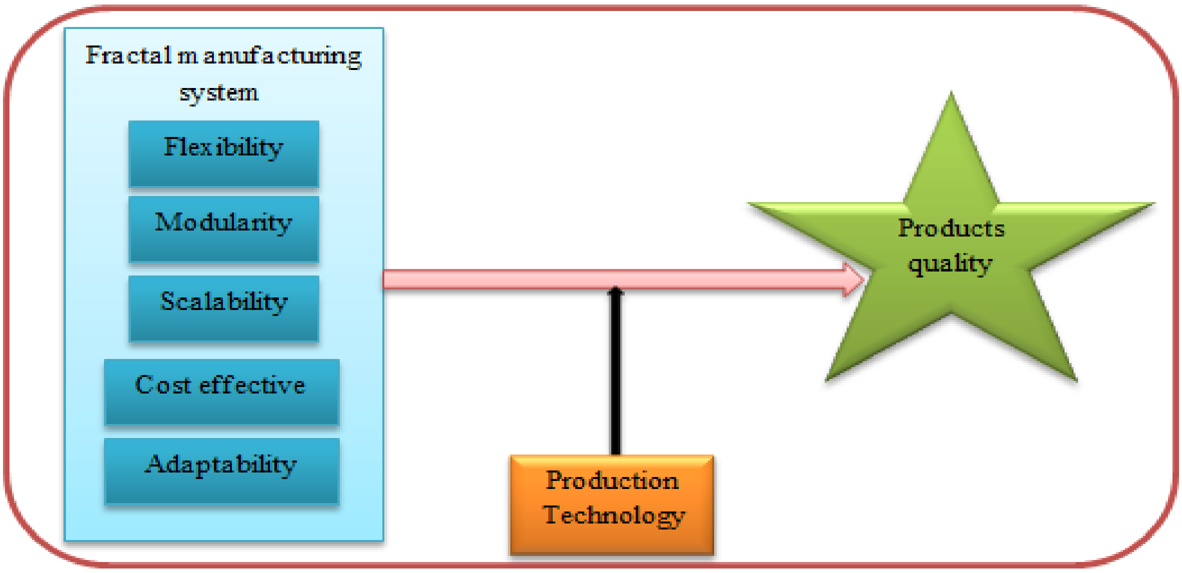
1- Introduce a conceptual framework on research variables (Fractal manufacturing system , Production technology and Products quality ).
2- Identify the requirements for applying the fractal manufacturing system in the respondent organization.

3- Description and diagnosis of the level of production technology present in the respondent organization.
4- Test the correlation and influence relationships between current search variables.

### *Procedural Chart and Research Hypotheses*

The procedural chart was designed for research and its hypotheses were formulated in accordance with the research problem, its importance, and objectives. The procedural diagram of the research is described as follows in Figure 1:

**Figure 1.** The procedural chart of the research




**Source:** Done by researcher

The hypotheses can be expressed thus:

1- There is a significant correlation between the five-dimensional fractal manufacturing system (flexibility, modularity, scalability, cost effective and adaptability) and both production technology and product quality.
2- There is a significant relationship of influence of the fractal manufacturing system in product quality through production technology.

### *Research Sample and Society*

The State Company for Electrical and Electronic Industries is a research community. It is one of the companies affiliated to the Ministry of Industry and Minerals, which was formed in 1997 by merging two companies: the General Company for Electrical Industries, which was established in 1967, and Al-Ezz General Company, which was established in 1991. Its purpose was satisfy the country's need for electrical and electronic devices and wireless communication devices. This company currently includes ten factories: a feeding industries factory, an air conditioner factory, an electronic and communication devices factory, a electromechanical equipment factor, a factory for transformers and fire extinguishers, a capable cables factory, a generator and super voltage factory, a Baghdad factory for home and office furniture, an engines and home devices factory, and a economic and renewable energy factory. As for the research sample, it consisted of members of the board of directors, factory managers and their assistants, managers of industrial lines, production engineers, design engineers, electrical engineers, electronic engineers and mechanical engineers. Their number reached 200 respondents.

## Theoretical Framework

### *Fractal Manufacturing System Concept*

The concept of a segmented manufacturing system was introduced for the first time by Warnecke (1993) as it indicated that every unit of the manufacturing system can be considered to supply a service, produce a product, or provide for other units, and that every part of the factory operates independently and has special goals (Strauss & Hummel , 1995: 288). Also, it can be defined as a set of self-identifying characteristics that can reorganize themselves into one or more of the most efficient and effective entities working to achieve the goal that they seek through cooperation, coordination and negotiation with others (Shin & Jung , 2009 :1029). Voss et al. (2017:3) pointed out that the fractal manufacturing system is one of the modern manufacturing models that have emerged in order to respond quickly to the manufacturing and market environment and the urgent need for flexible manufacturing systems that are adaptable and reusable. This system combines the characteristics of designing a large and diversified manufacturing system and high productivity while maintaining cost levels and the system's responsiveness to the market, as well as product quality. This is achieved by dealing with manufacturing systems that can be reconfigured, which ensures the maximum economic value of the organization in line with the organization's philosophy and culture (Koren , 2017:56). In the fractal manufacturing system, workstations are allocated to most manufacturing operations equally through segmented entities, and because this system provides very high flexibility, each cell can produce a specific product, which results in a high ability to deal with various products that meet the needs of the growing market. Thus, the number of these stations is close to the minimum, and the time used for handling is less, as well as the time spent in the design process (Peralta et al., 2015:928). Tharumarajah (1996:218) and Ryu & Jung (2004:2210) add that the industrial organization is divided when it consists of small components or fractal entities that have specific internal characteristics, which include:

1- Self-organization: It is embodied in the complete freedom of the parts in organizing and implementing the tasks to be performed, while the parts choose the styles and methods that are appropriate to address the problems they face in order to achieve self-optimization that takes into account the variables of the surrounding environment.
2- Dynamics: the parts adapt to environmental impacts without any major challenges in the organizational structure.
3- Self-Similarity: the similarities in the goals between the parts in order to coordinate between the objectives of the parts and their conformity with the general objectives of the parent organization.
4- Vitality
5- Self-dynamics
6- Efficient information systems as a result of adopting navigational techniques in approved databases such as data mining and data cubes to the treatment of tasks or to take advantage of the opportunities available to them.

Ahmed & Yasin (2010 : 1626) and Seely (2014 : 4498) emphasize that the fractal manufacturing system is characterized by high flexibility and rapid response with efficiency, effectiveness and reasonable cost through the accurate allocation of manufacturing resources in multifunctional cells or entities capable of processing a wide range of products so that the production of products is distributed to cells that all perform the same tasks. The process of continuous improvement is carried out with the various methods used in these cells in terms of the size of the resource needs, as well as the quality of the plans in place to implement the tasks in these cells or the fractal entities and work to get rid of all the extra activities that do not add value at a level that raises the quality of the completed operations. Tharumarajah (2003: 186) identified five dimensions of fractal manufacturing :

1- Flexibility: This is an area that allows the necessary changes to be implimented and to make appropriate improvements in response to a new situation imposed by the environment on the organization .
2- Modularity: Ease of swapping operations and introducing improved processes in addition to supporting components and operating resources.
3- Scalability: Increase or decrease the production capacity to adapt to the changing demand in addition to the ability to transform globally.
4- Cost effective: The lowest total cost of ownership (even if the cost of capital for the system is higher).
5- Adaptability: The ability to adapt in the event of an environment disorder so that the system is able to cope with this disorder and recover quickly.

***Production Technology Concept***

Before reviewing the concept of production technology, it is necessary to get acquainted with the concept of technology. Trott (2005 : 127) indicated that technology means machines, machinery, equipment, means, and procedures that help in converting inputs into outputs in order to achieve the strategic goals of the organization. Teece (2009 : 189) knew that it includes all the resources and technological knowledge that lead to the creation of new products or services for a specific organization. As for production technology, it is defined as a set of methods, tools and processes and equipment used to produce products and provide services, i.e. everything related to operating technology that deals with computer manufacturing technology, material handling and process transformation, whether manual or automated ( Henk et al.,2019:19). It is also a set of methods, rules, devices, machines, and equipment used in the manufacturing processes of products in order to maximize the performance dimensions of industrial organizations, that is, they use modern technology of machinery, programs and skills to produce designs that are developed with the required quality ( Stevenson , 2018:215 ). Production technology is of great importance through manufacturing, forming and assembling processes and analysis in reaching the final product with specifications, quantities, quality and pre-planned cost in order to reach the goals required to be achieved in the short and long term (Schroder & Goldstein, 2018:129).

Russell & Taylor (2011:235) pointed to the possibility of reducing costs through the use of production technology based on capital density, as costs include both operations and capital and operating costs. Production technology assists in providing support to the overall strategy of the organization by improving the operational strategy in achieving the organization's distinctive efficiency. Production technology also contributes to strengthening the competitive position of the organization through creativity and innovation, thus creating compatibility in the production process that leads, in one way or another, on competitive precedence (Heizer et al., 2017 :231). However, creativity in the field of production technology contributes to enhancing the competitiveness of the organization and makes it a pioneer in developing manufacturing operations so that these development processes give it a competitive advantage. For example, in the automotive industry, we find that the competitive advantage of Toyota is based, in part, on its new creative and flexible industrial operations that helped reduce a large part of its fixed costs, which gave it an advantage over its competitors (Buffa&Sarin,2001:103).

***Products Quality Concept***

Quality means doing things right, and concerns the quality of the good or service as perceived by the customer. The Operations Department strives to provide quality goods and services that comply with specifications in order to achieve customer satisfaction, which represents the most important part of the production plan. This comprises present and future customer needs

(Hollander et al., 2017:518). The quality is to avoid the loss that the product causes to society after it is sent to the customer, and this includes losses resulting from the failure to meet customer expectations and the failure to meet performance characteristics, as well as side effects caused by the product such as pollution, noise, etc. ( Beneke et al., 2013 : 219 ) . Some researchers pointed out that quality is the total mixture of the characteristics of a good or service that comes from marketing, engineering, manufacturing, and maintenance, through which the good or service in use will meet customer expectations. O'Neill et al. (2016 : 384) assert that the quality can be defined on the basis of the product as qualities or characteristics that can be measured and quantified. This can be on the basis of the user, which is an individual matter that depends on the user's preferences requested in the good or service, The products that provide the highest satisfaction to these preferences are the products of the highest quality, which on the basis of manufacturing, is defined as specifications and requirements that are related to manufacturing, operational and engineering practices, and is determined by design. Any deviation from these specifications is considered a decrease in quality. Quality in its general sense is the organization's production of a good or service with a high level of outstanding quality through which it is able to fulfil the needs and desires of its customers and in accordance with their expectations and achieve satisfaction and happiness for them. This is done through predetermined measures to produce the commodity, provide the service, and find a quality in it ( Abbey et al., 2015 : 488 ). The degree of brilliance and excellence, and the fact that the performance is excellent means that its properties or some of the characteristics of the product (Service & Commodity) is excellent when compared to the standards set from the perspective of the organization or from the customer's perspective, as it means achieving the goals and desires of customers constantly (Slack & Brandon-Jones , 2018: 462).

## Practical Framework

### *Characterization of Study Variables*

The current study used the questionnaire as a main tool for collecting data and information related to the opinions of the sample about the application of the segmented manufacturing system and its effects on the quality of products through production technology. 200 questionnaires were distributed. It was fully retrieved and, after verification, it was found that 169 questionnaires were valid for analysis. Therefore, in order to analyse the data, the study resorted to describing the study paragraphs, using a set of explanatory symbols that express the variables and dimensions of the study as in table 1 .

**Table 1:** Description of the variables included in the analysis

| Variable | Dimensions | Phrases | Symbol |
|---|---|---|---|
| Fractal manufacturing system ( FRMASY ) | Flexibility | 5 | Flex |
| | Modularity | 5 | Modu |
| | Scalability | 5 | Scal |
| | Cost effective | 5 | Cost |
| | Adaptability | 5 | Adap |
| Production Technology | One-dimensional | 12 | TEPR |
| Products quality | One-dimensional | 16 | PRQU |

***Normal Distribution Test of the Study***

Before analysing the data and extracting the necessary results, an important question must be answered, which is whether the results of the study can be generalized to the study community or not, and for the purpose of answering this question, the study resorted to the natural distribution test, which is one of the most famous measures by which the possibility of generalization can be clarified. The tests Kolmogorov-Smirnov, Shapiro-Wilk are among the most famous measures used for this purpose, as accepting or rejecting the test hypothesis depends on the moral value of these two tests, and if the value is higher than (0.05) this indicates the possibility of generalizing the results. If the number is less than 0.05, it is not possible. Table 2 shows the results of the normal distribution test for internal variables.

**Table 2:** Results of testing the normal distribution of internal variables

| Variable | Shapiro-Wilk | | | Kolmogorov-Smirnov[a] | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Flex | .855 | 169 | ***[1] | .280 | 169 | *** |
| Modu | .894 | 169 | *** | .219 | 169 | *** |
| Scal | .904 | 169 | *** | .176 | 169 | *** |
| Cost | .941 | 169 | *** | .148 | 169 | *** |
| Adap | .920 | 169 | *** | .143 | 169 | *** |
| FRMASY | .905 | 169 | *** | .191 | 169 | *** |
| TEPR | .913 | 169 | *** | .176 | 169 | *** |
| PRQU | .960 | 169 | *** | .099 | 169 | *** |

[1]( *** ) Value significantly above ( 0.05 ) .

The results of Table 2 show acceptance of the normal distribution test for the pulled data, as it is noted that the moral value of the two tests is higher than (0.05), and accordingly it can be said that the studied data is subject to the conditions of natural distribution, and therefore the results of the study can be generalized to society.

***Testing the Stability & Reliability of the Measuring Instrument***

The reliability of the measuring instrument is one of the common tests whose purpose is to measure the degree of consistency and homogeneity of the drawn data, while honesty refers to measuring the reliability of respondents in answering the study paragraphs. Perhaps the most famous measure used in these tests is the Cronbach Alpha parameter, which is requires the value extracted to be above (0.60) in order for the data to be named as stable and reliable. Table 3 shows Cronbach Alpha coefficients of the variables included in the study.

**Table 3:** Cronbach Alpha coefficients for the variables included

| Variable | Cronbach alpha variables | Internal honesty variables[1] | Dimensions | Cronbach Alpha dimensions | Internal honesty dimensions |
|---|---|---|---|---|---|
| FRMASY | 0.866 | 0.931 | Flex | .8880 | 0.942 |
| | | | Modu | .8860 | 0.941 |
| | | | Scal | .8990 | 0.948 |
| | | | Cost | .9030 | 0.950 |
| | | | Adap | .8870 | 0.942 |
| TEPR | 0.883 | 0.940 | One-dimensional | .8830 | 0.940 |
| PRQU | 0.882 | 0.940 | One-dimensional | .8820 | 0.940 |

[1] Reliability = The square root of the Cronbach Alpha coefficient

The results of Table 3 indicate that the value of the Cronbach Alpha coefficient came in conformity with the conditions, which is higher than (0.60). Therefore, it can be said that the questionnaire that was developed in order to measure the response of the study sample is characterized by stability and high reliability.

***Descriptive Statistics for Data***

1- Fractal manufacturing system

The results of Table 4 indicate that the general average of the mean of fractal manufacturing system is (3.51) and a standard deviation equal to (0.339), and the dimension that contributed to this is the Flexibility dimension with a somewhat high mean (3.73) and a standard deviation (0.362), while the reason for the gap in the decrease in fractal manufacturing system, which causes delay, may be caused by the adaptability, as it got the lowest mean (3.38) and a standard deviation equal (0.490).

**Table 4:** Descriptive analysis of the phrases of the fractal manufacturing system

| S | Mean | standard deviation | Importance order | S | Mean | standard deviation | Importance order |
|---|---|---|---|---|---|---|---|
| Flex1 | 3.94 | 0.564 | 1 | Scal4 | 3.36 | 0.991 | 4 |
| Flex2 | 3.76 | 0.540 | 3 | Scal5 | 3.31 | 0.952 | 5 |
| Flex3 | 3.78 | 0.592 | 2 | Scal | 3.45 | 0.456 | Third |
| Flex4 | 3.67 | 0.573 | 4 | Cost1 | 3.30 | 1.005 | 5 |
| Flex5 | 3.50 | 0.795 | 5 | Cost2 | 3.46 | 0.886 | 2 |
| Flex | 3.73 | 0.362 | first | Cost3 | 3.33 | 0.998 | 4 |
| Modu1 | 3.66 | 0.627 | 1 | Cost4 | 3.46 | 0.994 | 3 |
| Modu2 | 3.48 | 0.824 | 5 | Cost5 | 3.49 | 0.846 | 1 |
| Modu3 | 3.51 | 0.825 | 4 | Cost | 3.41 | 0.514 | Fourth |
| Modu4 | 3.64 | 0.720 | 2 | Adap1 | 3.46 | 0.951 | 2 |
| Modu5 | 3.59 | 0.834 | 3 | Adap2 | 3.18 | 1.014 | 5 |
| Modu | 3.58 | 0.458 | Second | Adap3 | 3.34 | 0.887 | 4 |
| Scal1 | 3.57 | 0.738 | 1 | Adap4 | 3.37 | 0.877 | 3 |
| Scal2 | 3.53 | 0.749 | 2 | Adap5 | 3.58 | 0.784 | 1 |
| Scal3 | 3.47 | 0.839 | 3 | Adap | 3.38 | 0.49 | Fifth |
| FRMASY | | | | | | | |
| Total mean | | 3.51 | | standard deviation Total | | 0.339 | |

2- Production technology
It is noted from the results of Table 5 that the general mean for the production technology variable is (3.53) with a standard deviation (0.396). Perhaps the phrase that contributed to this is the fifth phrase (TEPR5) with a somewhat high mean (3.71) and a standard deviation (0.621), while the reason for the production gap may be due to the first phrase (TEPR1), as it obtained the lowest mean (3.33) with a standard deviation of (0.897).

**Table 5:** Descriptive analysis of the phrases of the production technology

| S | Mean | standard deviation | Importance order | S | Mean | standard deviation | Importance order |
|---|---|---|---|---|---|---|---|
| TEPR1 | 3.33 | 0.897 | 12 | TEPR7 | 3.54 | 0.787 | 5 |
| TEPR2 | 3.71 | 0.685 | 2 | TEPR8 | 3.46 | 0.866 | 10 |
| TEPR3 | 3.55 | 0.771 | 4 | TEPR9 | 3.48 | 0.873 | 9 |
| TEPR4 | 3.54 | 0.866 | 6 | TEPR10 | 3.56 | 0.844 | 3 |
| TEPR5 | 3.71 | 0.621 | 1 | TEPR11 | 3.48 | 0.780 | 8 |
| TEPR6 | 3.45 | 0.859 | 11 | TEPR12 | 3.53 | 0.831 | 7 |
| TEPR | | | | | | | |
| Total mean | | 3.53 | | standard deviation Total | | 0.396 | |

3- Products quality

The results of the Table 6 indicate that the general average of the mean for the product quality variable (3.39) with a standard deviation (0.368). Perhaps the phrase that contributed to this is the first phrase (PRQU1) with a somewhat high mean (3.53) and a standard deviation of (0.845), while the reason for the production gap is the eleventh phrase (PRQU11) because it got the lowest mean (3.27) and a standard deviation (0.986).

**Table 6:** Descriptive analysis of the phrases of the Products quality

| S | Mean | standard deviation | Importance order | S | Mean | standard deviation | Importance order |
|---|---|---|---|---|---|---|---|
| PRQU1 | 3.53 | 0.845 | 1 | PRQU9 | 3.45 | 0.994 | 6 |
| PRQU2 | 3.35 | 0.840 | 12 | PRQU10 | 3.37 | 0.968 | 9 |
| PRQU3 | 3.43 | 0.924 | 7 | PRQU11 | 3.27 | 0.986 | 16 |
| PRQU4 | 3.47 | 0.880 | 3 | PRQU12 | 3.36 | 0.876 | 10 |
| PRQU5 | 3.29 | 0.972 | 15 | PRQU13 | 3.53 | 0.913 | 2 |
| PRQU6 | 3.37 | 0.910 | 8 | PRQU14 | 3.31 | 0.940 | 13 |
| PRQU7 | 3.36 | 0.948 | 11 | PRQU15 | 3.46 | 0.879 | 4 |
| PRQU8 | 3.29 | 0.954 | 14 | PRQU16 | 3.45 | 0.925 | 5 |
| PRQU | | | | | | | |
| Total mean | | 3.39 | | standard deviation Total | | 0.368 | |

***Measuring the Correlation between Study Variables***

In order to measure the consistency of the internal variables in the analysis, the study should resort to measuring the correlation coefficients between the fractal manufacturing system (independent variable) and its dimensions, production technology (intermediate variable), product quality (dependent variable) . Table 7 illustrates the correlation relationship matrix among the variables included in the analysis.

**Table 7:** Matrix correlation relationship between the variables included in the analysis

| Variables | Flex | Modu | Scal | Cost | Adap | FRMASY | TEPR |
|---|---|---|---|---|---|---|---|
| TEPR | .573** | .618** | .517** | .401** | .564** | .564** | 1 |
| PRQU | .655** | .595** | .503** | .400** | .600** | .600** | .670** |
| Sig. (2-tailed) = 0.000 N=169 | | **. Correlation is significant at the 0.01 level (2-tailed) | | | | | |

The results of table 7 indicate that there is a correlation between internal variables, as the correlation between the fractal manufacturing system and production technology reached (0.714), while between the fractal manufacturing system and the products quality is (0.732). The correlation between production technology and product quality is equivalent to (0.670), and the correlation between the dimensions of the fractal manufacturing system and other variables is as follows:

1- The strength of the correlation relationship between the dimensions of the fractal manufacturing system and production technology is that the highest correlation force is (0.618), which is due to the modularity dimension, while the lowest correlation force is (0.401) and is due to the cost effective dimension.
2- The strength of the correlation relationship between the dimensions of the fractal manufacturing system and the products quality indicates that the highest correlation force is equal to (0.655), which is due to the dimension of flexibility, while the lowest correlation force of (0.400) is due to the cost effective dimension.
It can be said that the studied company has to develop its capabilities in production technology by (0.286), as well as adding development as an added value to its capabilities in the quality of products by (0.268). This continuous improvement contributes to the representation of the fractal manufacturing system that is perfectly divided into production technology and product quality .

**Impact Relationship Test between the Input Variables**
***Direct Impact Relationship Test***

It is noted from the results of Table 8, and shown in Figure ( 2 ), that the presence of a direct impact of the fractal manufacturing system on products quality increases the fractal manufacturing system (FRMASY) by one standard weight and leads to an increase in product quality (PRQU) by (0.951) and a standard error of (0.242), i.e., with a critical value of (3.930), which means that the fractal manufacturing system has interpreted (0.595) of crises and phenomena that hinder the process of product quality development. Perhaps this matter, which stands without the development of the company studied in the products quality, is due to the decline in the cost of raw materials (the cost effective) that goes into manufacturing products, as these products are refunded. This indicates that the quality is poor, so the studied company has to review its production technology.

**Figure 2.** Standard model for testing the effect of fractal manufacturing system and dimensional on products quality.

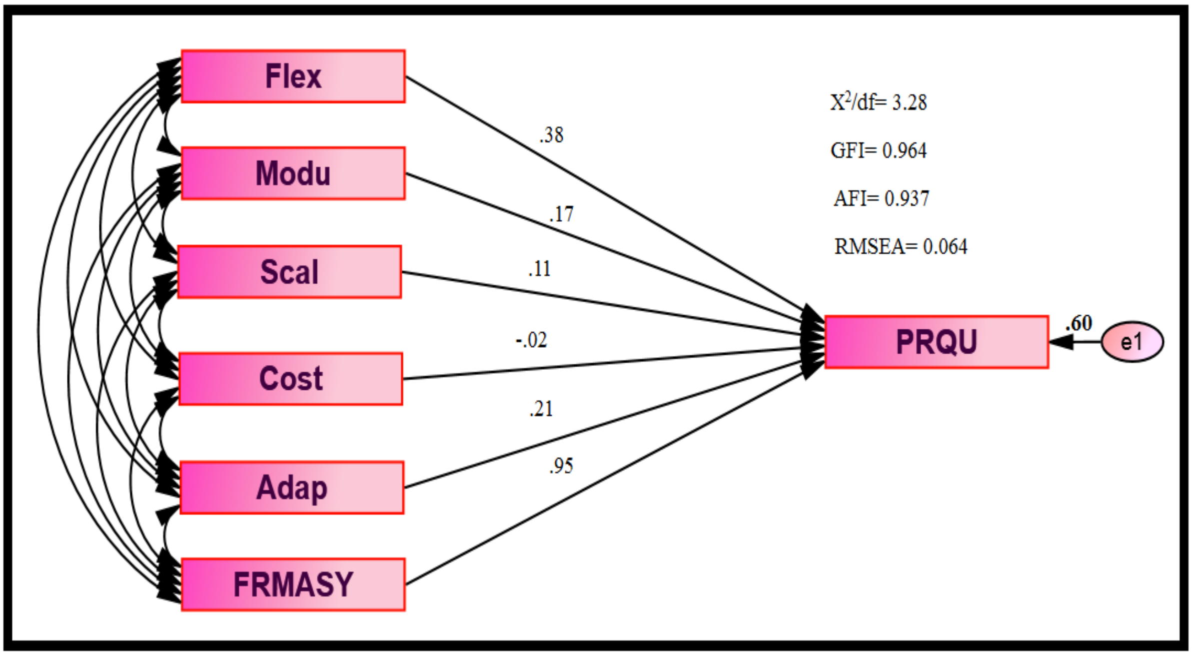


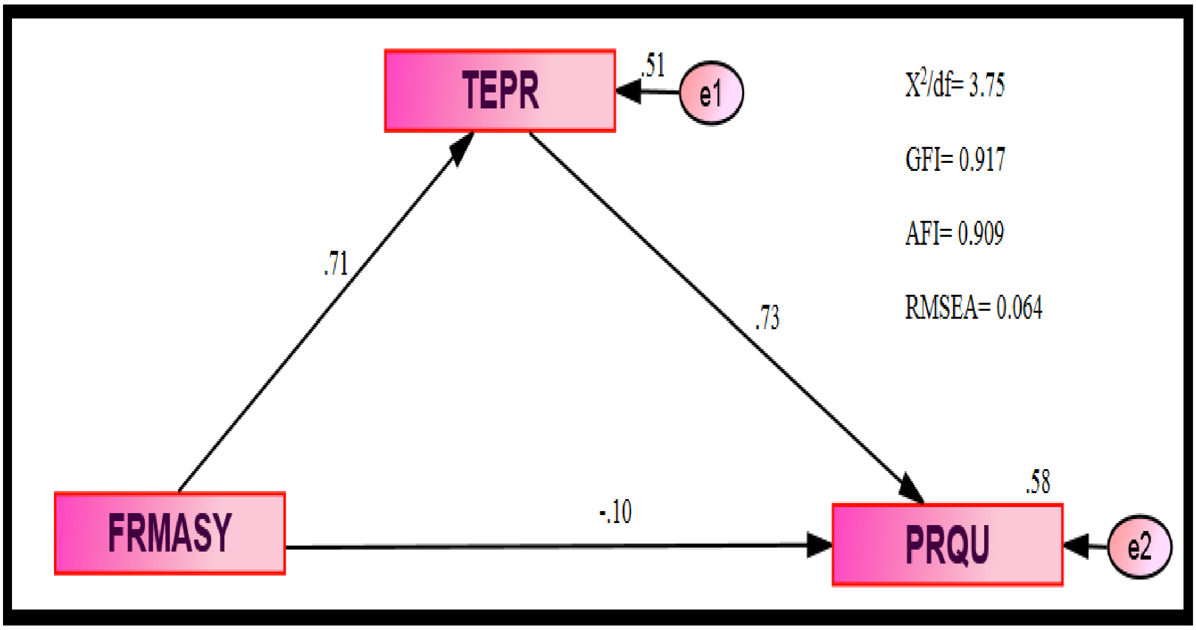
**Table 8:** Results of testing the effect of the fractal manufacturing system and its dimensions on products quality

| Path | | | Estimate | )$R^2$( | S.E. | C.R. | P |
|---|---|---|---|---|---|---|---|
| Flex | ---> | PRQU | .381 | .595 | .065 | 5.862 | *** |
| Modu | ---> | PRQU | .169 | | .053 | 3.189 | *** |
| Scal | ---> | PRQU | .114 | | .048 | 2.375 | *** |
| Cost | ---> | PRQU | -.022 | | .043 | -0.51 | n.s |
| Adap | ---> | PRQU | .207 | | .048 | 4.313 | *** |
| FRMASY | ---> | PRQU | .951 | | .242 | 3.930 | *** |

**Indirect Impact Test by Production Technology**

It is noted from the results of Table 9, which are shown in Figure (3), that there is a strong impact relationship between the fractal manufacturing system and the products quality by production technology, as increasing the fractal manufacturing system by production technology by one standard weight leads to an increase in products quality by (0.732) and, by mistake, a standard minimum amount of (0.078) and a critical value amounted to (9.385). The direct impact of the fractal manufacturing system on product quality without production technology was (0.100-), which means that the introduction of production technology has brought about a change in the entire production process, and has made a significant improvement (0.832) : $0.732 - (-0.100) = \mathbf{0.832}$

**Figure 3.** Standard model for testing the effect of a fractal manufacturing system in products quality through production technology



The results of the Table 9 indicate that the fractal manufacturing system mediated by production technology explained (0.580) of the obstacles that hinder the development of product quality.

**Table 9:** Results of testing the impact of the fractal manufacturing system in product quality through production technology

| Path | | | | | Estimate | )$R^2$( | S.E. | C.R. | P |
|---|---|---|---|---|---|---|---|---|---|
| FRMASY | >---- | | | PRQU | -.100 | 0.580 | .213 | -0.47 | n.s |
| FRMASY | >---- | TEPR | >---- | PRQU | .732 | | .078 | 9.385 | *** |

## Conclusions and Recommendations

### *Conclusions*

1- There is a correlation between the fractal manufacturing system and the product quality as well as production technology. Therefore, this matter creates good results between the internal variables of the study by enhancing the organization's capabilities to reorganize its internal units in a way that contributes to achieving core capabilities based on continuous improvement.
2- The existence of a direct impact relationship of the fractal manufacturing systems and its dimensions on the quality of products, which increases the organization's ability to devise different methods in order to enhance the organization's capabilities in improving the level of production during the period of peak demand for the products provided by the organization .
3- There is no direct impact relationship to the cost effective dimension of fractal manufacturing system in product quality, which requires the organization to follow indicators that contribute to improving the evaluation of the performance of the organization's internal operations in order to improve the principle of effective cost through creativity in designing and reducing lost and idle time for workers and machines .
4- The studied company contributes to the rapid transformation of production processes from the current product to the new product, which requires organizations to rearrange their resources in proportion to environmental changes. Therefore, this matter leads to the generation of more new market opportunities.
5- The studied company is interested in providing a variety of products, which must work to improve the level of production capacity in which it works in order to enhance demand and improve its capabilities to adapt to different requirements.
6- The studied company is keen on pricing the products according to the value provided to the customer, and therefore this matter leads to improving the company's ability to face fluctuations in demand for products.
7- The company’s lack of a set of methods to cope with the crises faced by its products. Therefore it must use the technology of the product to produce new products that were not previously produced.

***Recommendations***

1- The need for the company to work to improve the levels of its employees by developing their capabilities and skills in producing current products and in various ways.
2- The need for the company to adopt a diversification policy to obtain a good level of economies of scale and improve the efficiency of its products by defining diversification in accordance with the appropriateness of designs for the available technical capabilities.
3- The need for the company to contribute to improving the level of its production capacity, by improving its capabilities to adapt to the changing demands on products.
4- The company should work to improve its ability to quickly respond to customers' requirements in the external environment, therefore it is necessary for the company to use different technology to produce new products that have not been previously produced .
5- The necessity for the company to develop the scientific skills and experience necessary for its employees, and this is done through updating and developing production process technology and its suitability with the adopted production systems and the approved manufacturing strategy.
6- The need for the company's management to pay increased attention to the quality of the products offered by offering distinct products that contribute to the excitement and attraction of customers and urges them to repeat the buying process.
7- The company should contribute to the development of its capabilities to withstand external influences, by conducting research and development studies to detect the risks that may be encountered, and hinder the process of its development. Therefore, this matter contributes to developing appropriate solutions to meet threats in the future.

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