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The role of additive manufacturing technique in flexibility of supply chain performance an analytical study of the opinions of a sample of technicians who work in engineering offices and medical laboratories deployed in some Iraqi governorates

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ABSTRACT: *The study sought to search for The role of additive manufacturing Technique with its dimensions (Rapid prototyping, rapid manufacturing, rapid tooling), in flexibility of supply chain performance , in engineering offices and medical laboratories deployed in some Iraqi governorates (Baghdad, Babyl, Najaf, Karbala , Mosul, Erbil). The problem of the study was represented in the main question (what is the role of additive manufacturing Technique in flexibility of supply chain performance), and the study sample included the Technicians in engineering offices and medical laboratories, and data was gathered via the questionnaire after receiving (192) replies from Technicians in engineering offices and medical laboratories deployed in some Iraqi governorates, utilizing an intentional sampling method, the descriptive analytical approach was used in the study, and the data was then analyzed using statistical tools like the (arithmetic mean, standard deviation, linear correlation coefficient, simple and multiple regression coefficient), and (factor analysis, Alpha Cronbach) to test the scale. The results were obtained using statistical software like SPSS.V.27 and the program (Amos.V.26), and the study's findings were confirmed by them and the study's findings supported the notion that additive manufacturing technique contributes to the flexible of supply chains performance.*

Keywords - *additive manufacturing Technique, flexibility of supply chain performance*

المستخلص

تهدف هذه الدراسة الى البحث عن دور تقنية التصنيع المضاف بأبعادها (النماذج الأولية السريعة ، التصنيع السريع ، الأدوات السريعة) ، في مرونة أداء سلسلة التجهيز ، في المكاتب الهندسية والمختبرات الطبية المنتشرة في بعض المحافظات العراقية (بغداد ،بابل, النجف ، كربلاء ، الموصل ، أربيل). مشكلة الدراسة تمثلت في السؤال الرئيسي (ما هو دور تقنية التصنيع المضاف في مرونة أداء سلسلة التجهيز) ، وضمت عينة الدراسة التقنيين العاملين في المكاتب الهندسية والمختبرات الطبية ، وتم استخدام الاستبيان لجمع البيانات ،إذ تم الحصول على (192) استجابة من التقنيين العاملين في المكاتب الهندسية والمختبرات الطبية المنتشرة في بعض المحافظات العراقية و بأستخدام طريقة العينة القصدية، وتم اعتماد المنهج الوصفي التحليلي في الدراسة ، ومن ثم تم تحليل البيانات باعتماد بعض الطرق الاحصائية مثل (الوسط الحسابي ، الانحراف المعياري ، الارتباط الخطي. تم استخدام معامل الانحدار البسيط والمتعدد واختبار المقياس Alpha Cronbach) ، تحليل العاملي) ، وتم التوصل إلى النتائج باستخدام البرنامج الإحصائي مثل (SPSS.V.27) وبرنامج (Amos.V.26) كما أكدت نتائج الدراسة أن هناك دور لتقنية التصنيع المضاف في مرونة أداء سلسلة الجهيز. .

الكلمات الدالة *- تقنية التصنيع المضاف ، مرونة أداء سلسلة التجهيز*

I. INTRODUCTION

The escalating pace in the development of manufacturing and production processes in industrial organizations today is no longer just a luxury that organizations can dispense with or ignore, but rather the need to keep pace with this development and introduce its requirements of automation and techniques as well as theories to develop performance and improvement continuously is a real guarantee to achieve excellence in manufacturing and provide products with high quality. Recently, the additive

manufacturing Technique (AMT) has received great attention from many industrial sectors in developed countries, due to the wide leap achieved by this Technique in the field of verifying the validity of the initial designs of products before commencing the production process and manufacturing final products in one step or with much less of the steps required by traditional manufacturing processes, and stated(Alogla et al,2021:1), that the Supply chain (AMT) shows greater flexibility in product manufacturing through reduced turnaround time and lower cost of introducing a new product. This allows giving helpful information regarding the impact of implementing additive manufacturing process on supply chain flexibility in various disruption scenarios, we may help decision makers make timely judgments, Such include sudden market changes, demand uncertainty, lead time constraints, and product variety. Therefore, The fundamental objective of the current study is to explain the variables affecting the relationship between additive manufacturing technique and the flexibility of supply chain performance, that this study aims to address by responding to the following query (the role of additive manufacturing technique in flexibility of supply chain performance). and This main question has implicit ramifications, By presenting assumptions based on the intellectual and applied controversy in prior studies, the study was able to build a conceptual and hypothetical model that frames the relationship between the study's variables in a way that gives it importance and adds intellectual value to studies on production and operations management.

II. RESEARCH METHODOLOGY

1) THE RESEARCH PROBLEM

Since its inception in the late 1980s, AMT technique has advanced quickly, In spite of this, it took over two decades of development until AMT was on par with conventional production techniques, Over the years, technique has significantly fueled growth in the fields of entrepreneurship and technique, Prior to being made available to the consumer market by fresh open design firms, it initially catered to specialized industrial design markets, It made it possible to produce goods quickly and affordably in smaller quantities. As they don't require the resources needed by traditional manufacturing techniques, such as molds, fixtures, long production lines, etc., the time to make produce products has been reduced to a few days or hours thanks to this technology (Niaki&Noonino,2018:3). Also, understanding the supply chain pattern with regard to the intention of measuring the supply chain performance of industrial organizations, and this is what this study aims to do by responding to the following query.: (What is the role of additive manufacturing technique in flexibility of supply chain performance), and it seems to include the following sub-questions:

1. What is the Level of application of additive manufacturing technique for technicians working in the simple under study?
2. What is the level of application of supply chain flexibility performance in the simple under study?
3. Is there a significant effect of additive manufacturing technicians on the supply chain flexibility performance for the study sample?

2) THE RESEARCH IMPORTANCE

1. The industrial sector is considered one of the vital and rapidly changing sectors that need continuous improvement, especially in the Iraqi business environment. Therefore, conducting studies and research increases the chances of success and development of this sector.
2. The significance of the variables under study on both a theoretical and practical level in the field of production and operations management, as the study adds to the body of knowledge on subjects that are underrepresented in local and Arab libraries, such as the additive manufacturing technique , one of the most crucial issues in the modern industrial sector, and the flexibility of supply chain performance, As these variables receive great attention from researchers, and this enrichment is not limited to presentation and narration, but rather includes identifying the nature of the possible relationships between them, whether through discussion based on the logical and mental framework, or at the level of practical testing of a group of hypotheses by linking these variables.
3. we also hope that this research will benefit the industrial sector inside Iraq in forming an integrated framework that can be relied upon in diagnosing the method of dealing with additive manufacturing technique and the products it provides.

3) RESEARCH OBJECTIVES

1. Identifying the level of understanding with the dimensions of additive manufacturing technique (rapid prototyping, rapid manufacturing, rapid tooling) among the technicians who work in the engineering offices and medical laboratories of the study sample.
2. Determining the nature of technicians' awareness of the concepts of flexibility of supply chain performance in the light of the activities carried out by the engineering offices and medical laboratories of the study sample.
3. Verifying the influence relationship between additive manufacturing technique and flexibility of supply chain performance in the engineering offices and medical laboratories of the study sample.

4) Hypothetical Study Scheme

A hypothetical study outline has been prepared to reflect the relationship between the variables of the study, see figure 1, and therefore the variables of the study can be reversed in the following points:

1. The independent variable: Additive manufacturing technique is represented in three dimensions (rapid prototyping, rapid manufacturing, and rapid tooling).
2. The dependent variable: - flexibility of supply chain performance, and this one-dimensional change was measured.

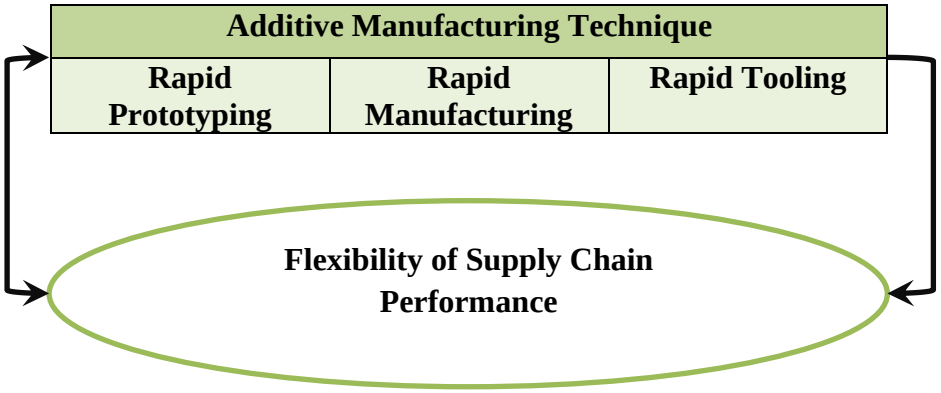

Figure 1 the hypothesis of the study

Source: Prepared by The Researcher

5) HYPOTHESIS OF RESEARCH

The Research dealt with two variables

H_{0-1} : There is a straight, positive, and significant relation between additive manufacturing technique and flexibility of supply chain performance.

H_{0-2} : There is a clear effect relationship between additive manufacturing technique and flexibility of supply chain performance.

III. study population and sample

A sample of 192 technicians who worked in engineering offices and medical labs were used in the study, In order to gather the required data the intentional sampling approach was used, and the sample size was established Out of the (221) questionnaires provided to the sample participants, the researcher retrieved (192) of them and They were gathered to prepare them for analysis.

First: Additive manufacturing technique

In the recent years, the manufacturing sector has created new methods and tools for the low-volume production of complicated and technically demanding items that are innovative, customized, and

sustainable. The additive manufacturing technique is one of these latest techniques. (Uriondo,2015:1). (steven,2020:257) pointed out that additive manufacturing technique is a computer-aided design (CAD) process that involves processes that create three-dimensional products by applying successive layers of materials to form a product. These materials can be of almost any size or shape. This techniqeu uses a set of processes in which a three-dimensional product is built through a computer-aided design (CAD) model, usually in a sequential manner, i.e. by adding one layer after another. Which provides more flexibility in product design, which eliminates design limitations, as it is a construction process of components added layer by layer, which are difficult to manufacture using traditional methods (pou et al,2021:40). (Heizer et al,2020:204) calls this technique 3D printing and He defines it as the use of computer aided design technique by adding raw materials layer by layer. These materials can be plastic, metal, ceramic, glass, or even human tissue. As for (Sun et al,2022:1) sees that this technique has a unique advantage represented in the manufacture of complex elements that are difficult to obtain through traditional manufacturing.

Second: The importance of additive manufacturing technique

The applications of additive manufacturing technique have greatly affected the automotive industry and the applications of designing tools and means to support production, especially in the field of medical manufacturing and the manufacture of human prostheses. (AMT) worked to improve efficiency, reduce production lead times, reduce operational costs, and build lightweight parts (Al-makky & Mahmoud, 2016:1). As for (Niaki & Nonino, 2018: 117), (Ford & Despeisse, 2016: 1581) they are sees the importance of additive manufacturing technique (AMT) in terms of its impact on operations strategy. Traditionally, this strategy aims at everything related to improving performance in terms of quality, flexibility, cost, and time, and. As organizations nowadays choose technique that provide different performance to achieve more competitive advantages, and (AMT) is the most important of these current technique that provide a number of important points of influence on the operations strategy. The importance of additive manufacturing technique is crucial to an organization a number of reasons, including (Sossou et al,2018:4),(Gao et al,2015:67)

1. The ability to design almost any complex geometric shape. This is in contrast to traditional manufacturing processes that restrict design due to the need for various fixtures and tools and the difficulty of reaching deep and invisible places in complex geometric shapes.
2. The accuracy of the dimensions of the derivation of the final of computer-aided design.
3. it give the great ability of the designer to design complex geometric shapes without additional costs, as there is no need for additional tools, re-installation, increased operator experience, or even an increase in manufacturing time.
4. Efficiency in time and cost in production processes.

Third: - Dimensions of additive manufacturing technique

1- Rapid Prototyping (RP)

Developments in laser technology and information and communication technology by the year 1990s, led to the first successful attempts of additive manufacturing technique (AMT) represented by rapid prototyping (RP), where parts with limited functions were produced as visual aids for product designers, and the great advantage of this (rapid prototyping RP) is the possibility of producing them very quickly from a 3D data se(Anderl et al,2017:9). (Najmon et al,2019:19) pointed out that rapid prototyping is They are models that allow verification of parameters of computer simulations of industrial parts. They are helpful for spotting design issues and openings that are only visible through the physical model, the majority of prototypes do not need to be made from the same materials as the final products, but they still need to be sturdy and precise enough to produce reliable test results. Models produced by polymer-based (AMT) methods like SLA or FDM are typically accurate enough to be tested as prototypes, Prototyping is a quick and affordable technique to evaluate physical characteristics and computational dynamic models because AMT may skip relatively expensive metal-based processes. As for (Haar,2016:15) sees It is one of the first uses of (AMT) to find a prototype that enhances product design, which manufacturers and product developers used to believe was a complex, tedious and expensive

process, and often this process hindered the stages of development and creativity while introducing a new product. So (RP) was found to greatly speed up this process and this term was adopted for it.

2- Rapid Manufacturing (RM)

Accompanying the maturity of (AMT) techniques in a range of attributes including quality, accuracy, speed, and cost, new application opportunities have emerged that define a second distinct classification for them. These improvements, along with improvements in the variety of materials available (and their performance properties) have enabled many organizations to successfully use additive manufacturing techniques in manufacturing end-production or end-use parts in quantities from one to thousands. Thus the Rapid Manufacturing (RM) designation has been adopted for this application(Eyers,2015:362). And (Ghazy,2012:7) indicated that rapid manufacturing is a process for producing product parts or finished products that can be used directly by customers using additive manufacturing technique. As for (Busachi,2017:147) sees that the origin of the term rapid manufacturing is due to their capability for (AMT) to produce and process complex engineering shapes designed in reasonable times and relatively low costs.

3- Rapid Tooling (RT)

The industry is compelled to compete effectively by lowering manufacturing times and costs while ensuring high quality products and services due to the pressures of highly competitive marketplaces. Rapid manufacturing methodologies—a term used to describe a variety of recent intelligent manufacturing techniques—have a great deal of potential for producing one-of-a-kind items, Compared to conventional production methods, these procedures combine advancements like computer numerical control, These systems have use not only in rapid production or prototyping development but also in tool manufacturing, Thus, new applications are referred to as Rapid Tooling Technologies (RT), which are meant to increase competitive advantage by lowering the time it takes for manufacturing and production processes to reach the market (Afonso et al, 2019: 1). And (Whelan,2021:32) pointed out that there is an increasing requirement for the cost-effective fabrication of tools capable of producing components in large quantities due to the continual development in demand for specialized production, According to expectations, (AMT) will enable companies to close the gap between the demand for new products that must be produced as fast and economically as feasible, and the related costs and lead times necessary to do so Rapid tooling (RT) and additive manufacturing technique (AMT) techniques, according to the claims, allow manufacturers to functionally test parts in finished materials within days after original design.

Fourth: The concept of flexibility of supply chain performance

A complicated network of nodes and linkages makes up the supply chain. It comprises a variety of organizational tasks and divisions, including buying, operations, information systems, and logistical services, to mention a few. Hence, businesses fight to improve their understanding of the supply chain, lower its risks, and increase its scalability. Hence, flexibility arises not just as a theory but also as a daily cultural necessity for enterprises. Thus, the organization's flexibility and strategy are impacted by the supply chain design (Singh et al,2019:3). (Stevenson,2021:42) emphasized the need of flexibility the capacity to adjust to change, These adjustments might be made in response to changes in client demand for volume or design elements of the product or service, or the organization's mix of goods and services, In a corporate climate that is changing quickly, having high flexibility might provide to orgnaization a competitive advantage.. As for (AminUllah,2019:41) indicated that a flexibility of the supply chain is the rapid response as a result to irregular changes in the market to establish or keep a competitive advantage, flexibility considered as a performance factor that considers how rapidly manufacturing companies can react to the particular demands of clients. It has become increasingly important to be flexible while developing new products. Some businesses compete by creating new items more quickly than their rivals. This calls for flexible supply chain partners that are eager to collaborate closely with designers, engineers, and marketers. and Supply chain response time can be measured by the number of days it takes the supply chain to respond to market changes without penalties and additional costs. And (Novais et al,2019:1792) sees that a flexible supply chain (SC) can standardize its operations and can effectively adapt to changing market conditions by responding to unforeseen changes in customer needs,

market dynamics, competitors' actions, and adopting a strategy that allows organizations to be able to offer individually tailored products and services to each customer.

Fifth: The importance of flexibility of supply chain performance

Many researchers see the challenge of balancing between efficiency and flexibility in order to effectively manage uncertainties in supply chain and factory disruptions. Therefore, ensuring a flexibility supply chain provides protection in the face of this challenge, and represents a logistics strategy to achieve a balance between efficiency and flexibility(Tiwari et al,2015:782). And (Manders et al,2017:11), (jafari et al,2022:13), (Khanuja&Jain,2022:6) they are sees that a importance flexibility of supply chain performance can be summed up in the following three points

1. With the growing significance of mass customization in modern companies, supply chain flexibility has emerged as one of the most crucial instruments for improving supply chain efficiency without raising prices.
2. Supply chain flexibility has become of major importance to organizations with the increase in outsourcing of processing and production processes in scattered parts of the world.
3. The importance of supply chain flexibility emerges as a strategic competency to deal with and react to unexpected events and is considered an indispensable feature of any modern and responsive organization with customers.
4. Flexibility significantly affects the product's quality, delivery, and speed to market, giving businesses an advantage over rivals, Moreover, a big supply base offers a more diverse and more comprehensive supply base to lessen the possibility of failure in unstable conditions, Flexibility in sourcing makes the organization more efficient at work when all its plans conflict with expectations, Thus, if suppliers can provide resources and respond to requirements in the required time, It increases the manufacturing companies' capacity, lowers the possibility of production interruptions, and eventually makes it easier to move commodities.

IV. the practical side of research

First: Coding and describing the study variables and their measures

The table (1) below shows the variables of the study and its dimensions included in the analysis and the symbols that express them, in a flexible way that facilitates the interpretation and understanding of the data and the conclusion of the purpose that the study seeks to achieve.

Table 1 Study variables and dimensions , and stability factors

Variables	Cronbach's alpha variable	Dimensions	NO.	Cod	Cronbach's alpha Dimensions	Source
additive manufacturing technique	0.897	Rapid Prototyping	6	AMRP	0.887	(Eyers,2015:361) (Lianos,2019:11)
		Rapid Manufacturing	6	AMRM	0.888	
		Rapid Tooling	6	AMRT	0.893	
flexibility of supply chain performance	0.887	one dimensional	5	SCFL	0.887	(Krajewski&Malhotra,2022:32)

Second: Confirmatory construct validity of additive manufacturing technique variable:

As the table (2) below shows, all the paragraphs of the variable of the added manufacturing technique got saturations greater than (30%) in three dimensions, and (18) paragraphs to settle at a matching quality index that attributed the chi_square value (X2) to the freedom degree (df). Its value is (1.240) to achieve the required criterion less than (5), with a good fit index (GFI = 0.950) greater than (0.90), and a corrected good fit index (AGFI = 0.936) greater than (0.90), and with an approximate root mean square error (

RMSEA = 0.073) higher than (0.05) and less than (0.08), and this shows that all indicators meet the standards set by (Hair et al., 2010).

Table (2) Standard saturations for the additive manufacturing technique variable

Path			Standard weights	Non-standard weights	S.E.	C.R.	P	Label
AMRP1	---->	Rapid Prototyping	.871	1.000				
AMRP2	---->	Rapid Prototyping	.884	1.496	.084	17.828	***	par_1
AMRP3	---->	Rapid Prototyping	.963	1.384	.063	21.838	***	par_2
AMRP4	---->	Rapid Prototyping	.984	1.363	.059	23.178	***	par_3
AMRP5	---->	Rapid Prototyping	.972	1.522	.068	22.423	***	par_4
AMRP6	---->	Rapid Prototyping	.974	1.271	.057	22.475	***	par_5
AMRM1	---->	Rapid Manufacturing	.960	1.000				
AMRM2	---->	Rapid Manufacturing	.980	1.033	.027	38.694	***	par_6
AMRM3	---->	Rapid Manufacturing	.940	.825	.028	29.450	***	par_7
AMRM4	---->	Rapid Manufacturing	.984	1.080	.027	40.122	***	par_8
AMRM5	---->	Rapid Manufacturing	.966	.890	.026	34.751	***	par_9
AMRM6	---->	Rapid Manufacturing	.936	1.054	.036	28.966	***	par_10
AMRT1	---->	Rapid Tooling	.960	1.000				
AMRT2	---->	Rapid Tooling	.979	1.121	.030	37.938	***	par_11
AMRT3	---->	Rapid Tooling	.960	1.043	.031	33.162	***	par_12
AMRT4	---->	Rapid Tooling	.982	1.153	.029	39.221	***	par_13
AMRT5	---->	Rapid Tooling	.929	1.208	.043	27.825	***	par_14
AMRT6	---->	Rapid Tooling	.954	1.093	.034	32.012	***	par_15

Third: **Confirmatory construct validity of Flexibility Of Supply Chain Performance variable:**

The table (3) below shows that all paragraphs of flexibility of supply chain performance variable explained through one dimension by (5) paragraphs obtained saturations greater than (30%) to settle at a matching quality index. The chi-square value (X2) was attributed to the degree of freedom (df).) with an amount of (1.785) to achieve the required criterion less than (5), with a good fit index (GFI = 0.939) greater than (0.90), and a corrected good fit index with

a value of (AGFI = 0.928) greater than (0.90), and with an approximate root mean square error index (RMSEA = 0.066) higher than (0.05) and less than (0.08), and this shows that all indicators meet the criteria set by (Hair et al., 2010).

Table (3) Standard saturations for Flexibility Of supply chain performance variable

Path			Standard weights	Non-standard weights	S.E.	C.R.	P	Label
SCFL1	---->	Flexibility Of Supply Chain Performance	.975	1.000				
SCFL2	---->	Flexibility Of Supply Chain Performance	.989	1.078	.022	50.002	***	par_5
SCFL3	---->	Flexibility Of Supply Chain Performance	.973	.967	.023	42.134	***	par_6
SCFL4	---->	Flexibility Of Supply Chain Performance	.982	1.141	.025	45.916	***	par_7
SCFL5	---->	Flexibility Of Supply Chain Performance	.917	.940	.034	28.012	***	par_8

Fourth: Statistical description of the additive manufacturing technique variable

The study sample's responses, which are displayed in table (4), reveal that they understood the importance of rapid prototyping dimension where it indicates the interest of technicians in engineering offices and medical laboratories deployed in some Iraqi governorates to invest in rapid prototypes in order to choose the best products to win the largest possible number of customers with a high arithmetic mean (4.11) to indicate the agreement of technicians working in engineering offices and medical laboratories deployed in some Iraqi governorates towards working on manufacturing rapid prototypes by achieving benefits for these offices and laboratories that they invest in expanding their fields of work, with a relative importance level of (82%) and with a good level of availability and standard deviation (0.771), where it became evident from the sample responses that all dimensions of the additive manufacturing techniques variable obtained a relative importance of 81%–82% and an arithmetic mean that varied between (4.05–4.11) to demonstrate that the study sample is aware of the role that additive manufacturing techniques play in flexibility of the supply chain performance.

Based on the table below, we see the general arithmetic mean for the additive manufacturing technique variable in the examined sample's responses was (4.08) with a standard deviation of (0.805), indicating that the sample understood the importance of implementing additive manufacturing in the manufacture technique of complex-designed products and then testing these products And marketing and achieving more economic benefits for engineering offices and medical laboratories, and this got a relative importance (82%).

Table (4) Matrix of descriptive statistics for additive manufacturing technique variable

S	Dimension	Arithmetic Mean	Standard deviation	Relative importance	Availability level,	Importance

1	Rapid Prototyping	4.11	0.771	82%	Available	1
2	Rapid Manufacturing	4.05	0.817	81%	Available	3
3	Rapid Tooling	4.09	0.805	82%	Available	2
Additive manufacturing technique variable						
Mean	4.08	Standard deviation	0.805	Relative importance	82%	

Fifth: Statistical description of flexibility of the supply chain performance variable

As shown in the table (5) below, the results indicate that the flexibility of the supply chain performance variable got a level of response towards agreement with relative importance (81%) and a high arithmetic mean (4.07) to indicate the interest of technicians working in engineering offices and medical laboratories deployed in some Iraqi governorates to increase distribution outlets, thus contributing to meeting the requirements The largest number of customers, as the answers of the study sample showed a standard deviation (0.832), and the paragraphs of the variable the flexibility of supply chain performance showed a good relative interest that ranged (80%-84%) to show the interest of technicians workers in engineering offices and medical laboratories spread in some Iraqi governorates to invest The distinguished skills of the workers in order to carry out more than one task, and this achieved a strong arithmetic mean with a range of (3.98-4.20).

Table (5) Descriptive statistics for flexibility of supply chain performance variable

Flexibility of supply chain performance variable					
Mean	4.07	Standard deviation	0.832	Relative importance	81%

Fifth: Testing hypotheses

First main hypothesis

There is a straight, positive, and significant relation between additive manufacturing technique and flexibility of the supply chain performance.

It is noted from the results of Table No. (6) that there is a rather strong correlation between the additive manufacturing technique and the flexibility of the supply chain performance and it was estimated strongly (0.776), while the strength of the correlation between the dimensions of the additive manufacturing technique and the flexibility of the supply chain performance ranged between (0.776) for the rapid manufacturing dimension to (0.762) for the rapid prototyping dimension. Which means the interest of technicians working in engineering offices and medical laboratories deployed in some Iraqi governorates to invest rapid prototypes in testing and developing products continuously, and greater interest in working on manufacturing products through additive manufacturing in order to ensure the continuity of the process of sustaining these products and helping customers achieve their personal requirements.

Based on the foregoing, it is possible to accept the first primary hypothesis, "There is a statistically significant association between additive manufacturing technique and the flexibility of supply chain performance), which means that the sample focuses on improving the ability to adapt to changes in the surrounding environment and investing the skills of the technicians working To produce the largest quantity of products in order to reduce costs.

Table (6) Correlation Matrix The relationship between additive manufacturing technique and flexibility of supply chain performance.

variables	**Flexibility Of Supply Chain Performance**

Rapid Manufacturing	0.776
Rapid Tooling	0.770
Rapid Prototyping	0.762
Additive manufacturing technique	0.776
****. Correlation is significant at the 0.01 level (2-tailed).**	

The second main hypothesis

There is a clear effect relationship between additive manufacturing technique and flexibility of supply chain performance.

It is noted from the results of Table (7) that the additive manufacturing technique dimensions model contributed to explaining the flexibility of supply chain performance by (0.602), indicating that increasing the additive manufacturing technique by one unit leads to an improvement (0.909) to enable technicians workers in engineering offices and medical laboratories Deployed in some Iraqi governorates to develop their capabilities to provide products with specifications that meet customer expectations and exceed their expectations by reducing the standard error rate (0.049) to the lowest possible extent and with a critical value higher than (1.96) to reach (18.551).

Table (7) Results of analyzing the effect relationship between additive manufacturing technique and flexibility of supply chain performance.

path			standard weights	standard error	critical value	R2	(P)
additive manufacturing technique	- - - →	flexibility of supply chain performance	0.909	0.049	18.551	0.602	0.001

VIII. Conclusions and Recommendations

Conclusions

1. The results showed that there is a significant correlation between additive manufacturing technique and flexibility of supply chain performance, It indicates that the research sample is mindful of the importance of additive manufacturing technique in improving flexibility of supply chain performance.
2. The study sample is interested in providing a higher value for its products in a way that maintains or enhances the product's capacity to respond to changes in the environment, which is evidenced by the presence of a direct and significant impact of additive manufacturing technique on the flexibility of supply chain performance.
3. The sample under study was interested in what customers thought of their products, and working to find modern ways to meet those needs, such as adapting deliveries that are consistent with the desires of customers on an ongoing basis.
4. The study's sample was aware of the importance of expanding distribution channels because doing so helps to satisfy the needs of the greatest number of customers.
5. The interest of the study sample in confirming the specifications of the products to the standards approved by the management of engineering offices and medical laboratories on an ongoing basis.
6. The researched sample aims to increase the ability to change the scheduling of production operations and at the same time taking care of delivering the products to customers on the agreed upon date.

Recommendations

1. The requirement for the studied population to understand how crucial the capability of the additive manufacturing technique to improve the flexibility of the supply chain, which requires the attention of the studied sample to direct the technicians working in the engineering offices and medical

laboratories deployed in some Iraqi governorates to address the problems of the business environment by responding to them with caution.

2. The study sample should be motivated to improve the economic situation of the engineering offices and medical laboratories and improving their profits, which requires them to urge the technicians working in it to enhance the awareness of the importance of the supply chain being flexible and able to respond to any changes that may occur in its business environment.
3. The sample under study must understand the value of having the capacity to adjust to environmental changes and to respond to shifting consumer tastes and preferences.
4. The research sample should focus on developing the ability of engineering offices and medical laboratories to change the scheduling of their production operations.
5. The study sample must be aware of the customers' attitudes toward its manufactured products through the additive manufacturing technique and its conformity with their expectations and the degree of its quality, and by measuring their level of satisfaction with the methods and timing of their requests.
6. The study sample should focus on expanding the flexibility of manufacturing processes to improve response to the requests of their customers by investing in additive manufacturing technique to exploit the skills of technicians who work in engineering offices and medical laboratories to carry out more than one task at a time.

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