أكاديمية السادات للعلوم الإدارية

مجلة السادات للبحوث الإدارية والمالية

Sadat Journal of Administrative and Financial Research

المجلد الثالث - العدد الثاني - يوليو 2025

Volume 3 | Issue 2 | Jul. 2025

sjsaf.journals.ekb.eg

رقم الإيداع بدار الكتب المصرية

24426

الترقيم الدولي الإلكتروني Online ISSN

2974-3389

الترقيم الدولي ISSN

2974-3370

مجلة السادات للبحوث الإدارية والمالية

الصادرة عن:

مركز الاستشارات والبحوث والتطوير - أكاديمية السادات للعلوم الإدارية

Exploring the Impact of Using Robotics in Supply Chain Management on Organizations' Operational Performance

دراسة تأثير استخدام علم الروبوتات في اداره سلاسل التوريد والامدادات على الأداء التشغيلي للمنظمات

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Sadat Journal of Administrative and Financial Research
Volume 3 | Issue 2 | Jul. 2025

Ministry of Higher Education
Sadat Academy for Management Sciences

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Abstract:

Digitalization has become a crucial technology across all sectors, leading to significant transformations. Businesses and consulting firms have recognized its potential within Supply Chain Management.

However, many organizations in Egypt are slow to adopt Digital Supply Chains. This hesitation stems from a lack of information regarding how to implement Digital Supply Chain solutions and the various benefits that digital technology can offer.

As a result, this research seeks to explore the connection between the use of robotics technology in supply chains and the operational performance of organizations, aiming to encourage top management to invest in Digital Supply Chains.

To validate this relationship, a survey was conducted among three companies to ensure comprehensive acceptance. The survey targeted three Egyptian companies in the field of food and beverages industry.

Statistical analysis was performed on the survey responses to assess the impacts of digitalization on various and different operational performance factors within the organizations.

Key Words: Digitalization-Digital Supply Chain-Robotics- operational performance of organizations.

أصبحت الرقمنة تقنية حاسمة عبر جميع القطاعات، مما أدى إلى تحولات كبيرة. وقد أدركت الشركات بشكل عام وشركات الاستشارات بشكل خاص إمكانياتها في إدارة سلسلة الإمداد. ومع ذلك، فإن العديد من المنظمات في مصر تتباطأ في اعتماد سلاسل الإمداد الرقمية.

نتيجة لذلك، يسعى هذا البحث لاستكشاف العلاقة بين استخدام تكنولوجيا الروبوتات في سلاسل الإمداد والأداء التشغيلي للمنظمات، بهدف تشجيع الإدارة العليا في كل المنظمات على الاستثمار في سلاسل الإمداد الرقمية

و للتحقق من هذه العلاقة، تم إجراء استبيان بين ثلاث شركات لضمان قبول شامل. استهدف الاستبيان ثلاث شركات مصرية في صناعة المواد الغذائية والمشروبات.
كما تم إجراء تحليل إحصائي على ردود الاستبيان لتقييم التأثيرات على عوامل الأداء التشغيلي المختلفة داخل المنظمات

الكلمات الداله :الرقمنة ـ سلسلة الإمداد الرقمية ـعلم الروبوتات ـ الأداء التشغيلي للمنظمات.

1- Research Outline:

In the upcoming section we will mention the research objectives,research problem,research hypothesis,research limitations, then the research methodology.

1-1 Research Objectives:

This study addresses a gap in existing literature by examining the connection between Robotics technology as a form of digital transformation in supply chains and its impact on operational performance, specifically regarding quality, productivity, and cost reduction. The thesis aims to establish a framework that illustrates this relationship to facilitate the implementation of Digital Supply Chains (DSC) in Egyptian companies.

This primary objective is divided into three specific sub-objectives:

1. To define Robotics as a technology for digital transformation.
2. To identify the key operational performance factors relevant to any organization.
3. To develop a structural framework illustrating how the use of Robotics in supply chain management affects Egyptian companies.

1-2 Research Problem:

Many organizations in Egypt are slow to adopt digital technologies in their supply chains. This delay is largely due to a lack of information on how to implement Digital Supply Chains effectively.

Compounding this issue is the scarcity of studies focused on digital supply chains and their effects on organizational performance. While numerous studies have explored traditional supply chains and their influence on operational performance, research specifically addressing the implementation of digital supply chains and their relationship to operational performance is limited.

Consequently, this research aims to explore the link between the digitalization of supply chains—through robotics technology—and organizational performance in order to motivate top management to invest in Digital Supply Chains.

1-3 Research Hypothesis:

The present research will test the following hypothesis:

There is a relationship between DSC technology of Robotics, and the organizations' operational performance.

1-4 Research Limitations:

- The research findings and results cannot be generalized as the questionnaire will focus only on a specific sector, so it won't encompass the other different sectors.
- The questionnaire will address only one Digital supply chain technology which was mentioned in the research hypotheses.
- The questionnaire will be applied to three companies in the food and beverage industry which have local factories in Egypt; those companies are : Edita-juhayna-Domty) (
- The time of the analysis period will be limited to the interval of thesis.
- The research findings and results cannot be generalized for other countries since it is limited to Egypt.

1-5 Research Methodology:

The research methodology will combine both of the qualitative & quantitative approaches by taking the following steps:
- A literature review on Digital Supply Chain (DSC) and organization operational performance.
- Identification of the most important DSC new technologies based on an extensive literature review.
- Identification of the main important measures of an organization operational performance.
- Proposing a structural model relating the DSC new technologies and organization operational performance.
- Design of a survey (questionnaire) for data gathering concerning both DSC new technologies and organization operational performance
- Application of survey on food and beverage sector (industry).

- Use of different statistical analysis models to check the data validity and reliability, and to find the impact of the robotics technology on organization operational performance in the proposed structural model.
- Deduction of the verified structural model that shows the relationship between the DSC new technology which is the Robotics (as independent variables) and the organization operational performance measures (as dependent variables)

Discussions, conclusions, findings, and recommendations. -

2- Introduction:

Technology has progressed rapidly in recent years, making digitalization essential for all sectors. The digitalization of supply chains is anticipated to expand significantly and become vital in supply chain management (SCM). Many companies are striving to embrace digital tools after recognizing their importance for business growth. They feel the pressure to adapt or risk falling behind (Akkerman, D., 2021 ; AlNuaimi, et.al,2022).

However, numerous organizations remain unsure about how to implement digital technologies, as they continue to rely on conventional supply chains. While traditional supply chains primarily plan and react, digital supply chains are capable of predicting outcomes and recommending actions. Conventional supply chains are mostly static, operating on rules derived from past transactions, whereas fully digital supply chains function in real-time, are dynamic, and can adjust to evolving conditions. Unlike the linear nature of traditional supply chains, digital supply chains operate as interconnected networks (Djanian, M., & Ferreira, N. ,2020).

Moreover, traditional supply chains often utilize isolated systems, while digital supply chains integrate information from IT and operational technology (OT) systems. Rather than optimizing individual nodes, shipments, or orders, digital supply chains focus on balancing profitability with service levels.

In a conventional supply chain, identifying potential issues and forecasting their impacts can be labor-intensive. Conversely, in a digital supply chain, shared quality and control data from suppliers allow companies to anticipate problems and respond proactively, minimizing the need for extensive pre-planning. SCM involves the planning and management of all activities related to sourcing and procurement, conversion, and logistics, requiring coordination and collaboration with various stakeholders, including suppliers, intermediaries, third-party providers, and customers (Forradellas Reier, R.F. and Garay Gallastegui, L.M., 2021).

Importantly, decisions in traditional supply chains are made by humans based on machine data, while in digital supply chains, machines take the lead in decision-making, with human oversight.

Despite the clear benefits of digital technology, many companies are reluctant to invest adequately, with a significant portion of revenue still derived from traditional management practices. Over the last decade, SCM has gained attention from senior management in many industrial firms, and academic interest in the field has grown, focusing on various aspects such as supplier selection, involvement, alliances, upstream research, manufacturer-retailer relationships, supply chain resilience, and sustainability. However, the potential of digital supply chains remains underexplored (Lamarre, E., Chheda, S., Riba, M., Genest, V., & Nizam, A.,2023)

Understanding the complexities of supply chain digitalization and its effects on operational performance is crucial. As this area is still developing, there is ample opportunity for further study. Research that provides empirical evidence regarding the impact of digital supply chains on operational performance is increasingly urgent (Guo,D, et.al, 2020).

The digital supply chain represents a novel approach leveraging innovative technologies to transform traditional supply chain operations, leading to better integration among members. Key technologies influencing the digital supply chain include Cloud Computing, blockchain, the Internet of Things (IoT), Robotics…. In this paper we will focus only on one techmology which is Robotics.

According to Copestake.A, et.al,(2022),to assess supply chain performance, companies should focus on financial metrics such as costs, profitability, revenue, and return on investment, as well as non-financial metrics like process quality and flexibility. Previous studies have identified quality, productivity, and cost as critical performance factors.

3- Robotics Technology:

Robotics is an interdisciplinary field that merges electronics, computer science, and engineering, focusing on the design, construction, operation, and application of robots. The primary goal is to create machines that assist humans. This field incorporates mechanical, electrical, information, mechatronics, biomedical, computer, control systems, software engineering, and mathematics (Vidal, J. F., et.al, 2022)

Robots can replicate human actions and are used in various contexts, especially in hazardous environments, manufacturing, or places unsafe for humans, such as space and underwater. Many modern robots are designed to resemble humans, which can enhance their acceptance in tasks typically performed by people. They emulate actions like walking, lifting, and speaking. A branch of robotics, bio-inspired robotics, draws inspiration from nature (Win S. foong, 2022).

Some robots require human input, while others operate autonomously. The concept of autonomous robots has historical roots, but significant research into their functionality has only gained traction in the 20th century. Scholars and engineers have long envisioned robots that could mimic human behavior and perform tasks similarly. Today, robotics is a rapidly evolving field, with ongoing research and development aimed at practical applications in domestic, commercial, and military contexts. Robots are often employed in dangerous jobs, such as bomb disposal and disaster recovery. Additionally, robotics plays a role in STEM education (Schliro, D.,2024)

3-1 Robotics Aspects:

According to McKinsey (2022), various types of robots exist serving numerous environments and purposes. Despite their diverse applications and designs, they share three fundamental similarities in their construction:

- Mechanical Structure: All robots possess some mechanical framework or design tailored for specific tasks. For instance, a robot meant to traverse muddy terrain might utilize caterpillar tracks, while origami-inspired robots are capable of sensing and analyzing in extreme conditions. The mechanical design is primarily a solution by the creator to fulfill the intended task while navigating environmental physics, adhering to the principle that form follows function.

- Electrical Components: Robots include electrical elements that power and control their mechanisms. For example, the caterpillar track robot requires electricity to operate its tracks, which is supplied by a battery through an electrical circuit. Even gasoline-powered machines need electric current to initiate combustion, which is why vehicles typically have batteries. The electrical components facilitate movement (via motors), sensing (using electrical signals for measurements like temperature and position), and overall operation, requiring a certain level of electrical energy for basic functions.
- Computer Programming: Every robot includes some level of programming that dictates when and how it performs tasks. For instance, while a robot with caterpillar tracks may be mechanically and electrically equipped to move through mud, it relies on programming to initiate movement. The efficacy of a robot hinges on its programming; even with superior mechanical and electrical components, a poorly structured program will lead to subpar performance. There are three main types of robotic programming:
- Remote Control: Robots that operate based on a predefined set of commands activated by human input.

- Artificial Intelligence: These robots can autonomously interact with their environment, responding to various stimuli based on their programming.
- Hybrid: This combines both AI and remote control functionalities.

3-2 Robotics Advantages:

Matson (2020) and Schiliro (2022) have stated in their researches that the main advantages and benefits resulting from using Robotics are as follows:

- Enhanced efficiency and accuracy for employees working alongside robots, reducing data analysis errors.
- Improved repeatability, reproducibility, and quality across office processes.
- Automation of routine tasks allows employees to focus on more complex duties, raising the standard of repetitive tasks.
- Increased time for employees to engage in creative problem-solving, with business processes accelerating up to tenfold.
- Rapid results from Robotic Process Automation (RPA), even in organizations facing technological debt.
- Automated checks based on predefined rules for validation points.
- Seamless operation across multiple systems, integrating various applications (e.g., PDFs, MS Excel, ERP systems).
- Opportunities for analytics integration.
- Custom solutions for individual users, including secure information extraction from emails.
- High reliability of software robots adhering strictly to predefined workflows, enhancing process reliability and compliance.
- Broad applicability across industries, notably in accounting, finance, banking, insurance, telecommunications, and logistics.
- Decreased operational costs.

3-3 Using Robotics Process Automation (RPA) in Supply Chain Management:

In supply chain management (SCM), particularly in retail, numerous manual processes seek technological improvements for enhanced accuracy and productivity. Software robots can automate various retail functions, including customer support.

Implementing RPA demonstrates efficiency in SCM by streamlining order tracking and providing timely updates to customers. It also automates customer feedback collection, improving satisfaction. Efficient automation facilitates return management, inventory adjustments, and the customer lending process. In accounting, RPA can automate tasks like debt collection, receivables management, reconciliation, and financial reporting.

RPA is useful for various analytical functions, such as campaign performance and consumer behavior analysis. It can also automate planning data collection, data cleansing, simulation runs, exception identification, and communication of planning data to stakeholders. In logistics, RPA monitors inventory, tracks shipments, and communicates with customers/suppliers based on predefined events (Copestake, A., Estefania-Flores, J., & Furceri, D. 2022).

In logistics, RPA can automate transport management, effectively tracking goods in transit and providing insights about carriers and insurance companies through statistical data. In manufacturing, RPA aids in managing information from material lists and resolving low-priority customer inquiries through automated data entry and email communication. ERP automation enhances report generation and streamlines tasks across inventory, supplier, and customer management functions.

RPA can digitize and migrate data from legacy systems to ERP systems with high accuracy, offering valuable statistics on SCM processes and identifying bottlenecks for improvement (Marr, B.,2023)

3-4 Benefits of RPA in Supply Chain Management:

RPA presents numerous advantages, particularly in SCM, aiming to streamline automation by integrating software robots with user interfaces rather than application code. RPA addresses systematic automation challenges stemming from repetitive tasks. Key benefits of RPA technology include accuracy, improved employee morale, productivity, reliability, consistency, non-invasive implementation, compliance, and low technical barriers (Rêgo, B. S.,et.al, 2022, Schilirò, D., 2022).

Key Benefits of RPA in SCM:

- Accuracy: RPA significantly enhances operational accuracy by minimizing procedural errors. Well-programmed and tested robots consistently execute tasks, marking errors when deviations occur.
- Consistency: RPA can automate repeatable, rule-based SCM processes with high precision and speed, ensuring reliable results.
- Compliance: RPA adheres to compliance regulations through sequential actions, maintaining audit trails and enabling quicker identification of issues, thereby enhancing business improvement.

- Compatibility: The ability of robots to interact with interface components depends on their programming. Compatibility challenges can hinder RPA adoption, but successful implementation can boost productivity.
- Programming Time: Effective RPA requires initial programming, necessitating internal expertise and identification of suitable application areas.
- Organizational Consistency: RPA is procedural, requiring well-organized digital structures to avoid errors. Proper file paths and naming conventions are crucial for effective robot programming.

3-5 The Role of RPA in the Food Supply Chain:

Contemporary challenges such as sustainability, food safety, and food security require RPA applications that extend beyond the farm to encompass the entire supply chain. Enhancing farm efficiency alone does not guarantee consumer benefits without a robust distribution network. However, most studies focus on RPA applications at the farm level, reflecting industry constraints.

A typical food supply chain involves numerous partners, including farmers, suppliers, packers, importers, exporters, retailers, and consumers. This complexity results in extensive interactions and information sharing. Many firms in the food supply chain are small and medium enterprises with limited financial resources, complicating collaborative RPA adoption. Furthermore, these systems require appropriate information infrastructure, which can be a technical barrier for food companies (Schiliro, D., 2022)

RPA applications within food supply chains are still nascent, as indicated by the limited research available. This aligns with findings from studies on Big Data and Industry 4.0 in agriculture, which note constraints related to finances and manpower. Additionally, research on blockchain technology has shown that its implementation in food supply chains remains in the testing phase.

The food sector's high standards for safety and hygiene processes present challenges for RPA implementation. Variability in food products' shapes and sizes complicates measurement methods for ingredients and recipes. While RPA holds promise, efforts to reduce human involvement in these tasks have often failed due to issues such as high costs and the availability of qualified personnel. Future research should explore the barriers to RPA adoption in the food supply chain (Matson, 2020).

4- Digitalization and Organizational Performance:

Literature indicates that digital technologies influence firm performance through various factors, enhancing both product offerings and operational processes. These technologies encompass ICTs and advanced manufacturing systems.

A framework has been proposed linking value creation to ICTs, highlighting variables such as product improvements, process standardization, and responsiveness. They demonstrated that ICTs significantly impact value creation. Other studies also identified a positive correlation between ICT use and performance. The relationship between ICT adoption and productivity growth appears positive across various industrial sectors. However, while evidence suggests a strong link between ICT and performance, establishing clear causality remains challenging.

Advanced manufacturing technologies involve the use of mechanical, electronic, and computer systems for production control (e.g., CAD, robotics, flexible systems, and numerical control). These technologies allow for both standardization and customization, and their effective implementation is recognized as a means to achieve sustainable competitive advantage (Astill, J., R. A. Dara, M.Campbell, J. M. Farber, E.D.G. Fraser, S. Sharif, and R. Y. Yada. 2019).

5- Factors Influencing Organizational Operational Performance:

As previously noted, organizations assessing operational performance should focus on both financial metrics—such as costs, profitability, revenue, and return on investment—and non-financial metrics like process quality and flexibility (Allena, M. 2020 and Hobbs, J. E. 2020).
Past researches highlight quality, productivity, and cost as key performance factors, which are also the three dependent variables in our thesis model. These factors will be discussed in detail in the following sections.

5-1 Quality:

Quality is a subjective term, often described as being in the "eye of the beholder." Its interpretation varies depending on individual perspectives and contexts. For instance, in manufacturing, quality may differ from its definition in service organizations (Marr, B. 2023).

Understanding Quality:

Quality can be defined as providing a product that meets design and functionality standards. A product is considered to have the minimum expected quality if it operates as intended.

In manufacturing, quality is often characterized by doing things right the first time, where processes are designed to meet specific standards and requirements. Likewise, in service delivery, quality may be assessed in terms of the speed of service, reflecting customer satisfaction regarding timely fulfillment.

From the customer's viewpoint, quality measures how well a product or service meets expectations. High customer satisfaction indicates that a product or service meets the defined quality standards.

Operationally, reducing costs and minimizing waste are considered quality performance indicators, as they relate to efficiency. Effective operations that minimize waste contribute to higher quality performance.

Quality can also be evaluated based on adherence to policies, procedures, and standards. Complying with required specifications is essential for achieving expected quality levels.
In summary, quality encompasses product and service excellence, operational efficiency, and adherence to standards, reflecting the pursuit of perfection in performance (Sarkis, J., Cohen, M. J., Dewick, P., & Schröder, P. 2020).

5-2 Productivity:

Productivity in a production process refers to the efficiency with which goods and services are produced. It is typically measured by comparing total output to a single input or total input to total output over time. Essentially, productivity gauges how efficiently a person or organization completes tasks, often assessed based on the resources (labor, capital, energy) utilized to produce goods and services. In economic terms, productivity reflects the output per unit of input and serves as a key driver of economic growth and competitiveness. At the organizational level, productivity can be quantified by comparing the number of units produced or net sales to the labor hours invested (Setyowati, M. S., Utami, N. D., Saragih, A. H., & Hendrawan, A. 2020).

5-3 Cost:

Cost management is essential for organizational performance, as profitability is determined by both costs and revenues. Organizations transition from loss to success by achieving profitability, which in turn provides the necessary funds for growth and sustainability during challenging times.

Organizations can enhance profitability through various management strategies, including effective planning, sourcing quality materials, optimizing technological processes for productivity, managing consumption and waste, maintaining equipment, producing quality products, training motivated staff, marketing effectively, managing finances, and making sound decisions (Surender, K. & Goel, A., 2022).

6- Data Analysis:

The upcoming part will includes data analysis by using some statistical methods and tests to verify the validity of the study's hypothesis stemming from the general objectives of the thesis, with the aim of measuring the relation between Digital Transformation of Supply Chain and Organizations' Operational Performance .It will end with the study results.

6-1 Preliminary analysis of the data:

When collecting primary data from the questionnaire list, data processing or preliminary data analysis is a key step required before conducting subsequent statistical analyses. Preliminary analysis of the data is critical to ensure that subsequent statistical analyses will be carried out correctly.

The preliminary analysis of the data was established based on the following stages:

1 Reliability and Validity tests

2 Identify the statistical methods used in data analysis

Reliability and Validity tests

Both Reliability and Validity tests are usually conducted with the aim of knowing the validity, soundness and cogency of the survey list for conducting subsequent statistical analyses, and the following is an explanation of each of the reliability and validity coefficients.

• Reliability test:

Reliability refers to the extent to which the statements (statements) of the survey list are stable and do not contradict themselves, that is, the survey list will give approximately the same results with a probability equal to the value of the reliability coefficient if it is re-applied to another sample of the same population and the same size.

To test the reliability of the statements in the survey lists, Cronbach's Alpha was used, a parameter that takes values ranging from zero to one. If there is no stability, then the value of this parameter will be equal to zero, while if there is complete stability in the data, then the value of this parameter will be equal to one.

That is, an increase in the value of Cronbach's alpha coefficient and its closeness to one means an increase in the level of data credibility to reflect the results of the sample on the population under study. Note that the lowest value of the reliability coefficient is 0.7, and more than 0.7 gives a strong indicator to judge the reliability of the survey list, however, values greater than 0.6 are considered acceptable values as well.

The Cronbach's alpha coefficient is calculated using equation (1):

$$Alpha = \frac{\mathrm{n}}{\mathrm{n} - 1}\left(1 - \frac{\sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{Vi}}{\mathrm{Vt}}\right)$$

Whereas:

Alpha stands for Cronbach's alpha coefficient.

n stands for the number of statements in the survey list.

V_i stands for one-statement variance.

V_t stands for the variance of all statements in the poll list.

Validity test:

The validity of the survey list means that the statements in the survey lists represent the well-studied population, that is, the answers obtained from the survey lists give the information for which the statements are made (the survey list measures what they are supposed to measure).

The validity coefficient is measured by taking the square root of the reliability coefficient as shown in equation (2).

$$Validity = \sqrt{\mathrm{Alpha}}$$

Table (1) shows the results of applying both the reliability and validity tests at the level of the study variables.

It is clear from Table (1) that the value of each of the reliability and validity coefficients exceeds 0.6, at the level of all variables, which indicates that there is stability in the statements for each variable, and the survey list measures what it was designed to measure and therefore it represents the study population in a good way. so the data of that list can be relied upon in the work of subsequent analyses and statistical tests.

Table (1): The results of applying the reliability and validity coefficients

Source: Developed by the researcher, 2024.

Variables	Dimensions	No. of statements	Reliability coefficients	Validity coefficients	
				$\sqrt{Alpha}$	r
DSC Technologies (X)	Blockchain Technology	11	0.990	0.995	0.984**
	IoT Technology	9	0.763	0.873	0.702**
	Robotics Technology	10	0.989	0.994	0.984**
	The variable as a whole	30	0.978	0.989	0.994**
Operational Performance Factors (Y)	Quality Performance	4	0.986	0.993	0.989**
	Productivity Performance	4	0.924	0.961	0.987**
	Cost Reduction	4	0.964	0.982	0.981**
	The variable as a whole	12	0.984	0.992	0.994**
The questionnaire variables as a whole		42	0.988	0.974	--

6-2 Confirmatory factor analysis (CFA) of study dimensions:

This type of analysis is used to test the existence or absence of a relationship between the items of each dimension, as well as evaluate the ability of the model to express the data set and the results were as follows:

6-2-1 Confirmatory factor analysis of independent variable DSC Technology (Robotics):

The researcher performed the confirmatory factor analysis of the independent variables DSC Technology (Robotics) to test the existence or absence of a relationship between this dimension and the items of this dimension, as well as evaluate the ability of the model to express the data set.

Robotics Technology Variable:

The following figure shows the confirmatory factor analysis of Robotics Technology variable:

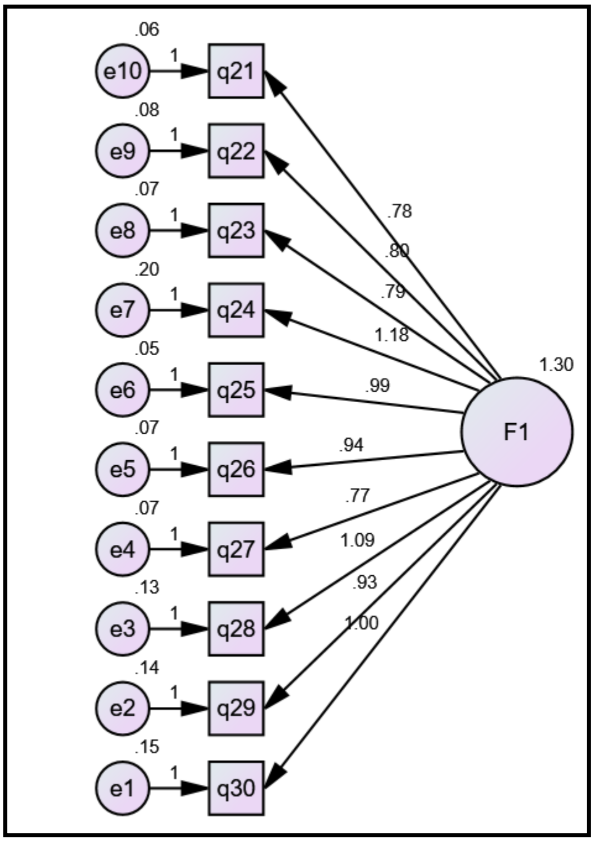

Figure (1): The Confirmatory Factor Analysis of Robotics Technology Variable

Source. Developed by the Researcher

We conclude from the previous figure the Model Fit Summary:

Table (2): The Quality Indicators of The Model Fit Summary

Measure	Estimate
CMIN	977.083
DF	35
CMIN/DF	27.917
GFI	0.573
CFI	0.847
TLI	0.803
RMR	0.028

From the previous table:

The Goodness of Fit Index (GFI) is equal to (0.573) and these values close to 1 and a value of 1 indicates a perfect fit.

The Comparative Fit Index (CFI) is equal to (0.847), which falls in the range from 0 to 1 and CFI values close to 1 indicate a very good fit.

The root mean square residual (RMR) is equal to (0.028), RMR values close to 0 indicate a good fit, which the value of (RMR) equal to zero indicates a perfect fit.

The Tucker-Lewis coefficient (TLI) is equal to (0.803), and the typical range of this coefficient is between zero and one. TLI values close to 1 indicate a very good fit.

The results show that:

There is a correlation between the Robotics Technology Variable and its items and all the quality indicators of the model achieved an acceptable level some came close to the required level.

6-2-2 Confirmatory factor analysis of dependent variable Operational Performance Factors (Quality Performance, Productivity Performance, Cost Reduction):

The researcher performed the confirmatory factor analysis of the dependent variables DSC Technologies (Quality Performance, Productivity Performance, Cost Reduction) to test the existence or absence of a relationship between the three dimensions and their items of this dimensions, as well as evaluate the ability of the model to express the data set.

Quality Performance Variable:

The following figure shows the confirmatory factor analysis of Quality Performance variable:

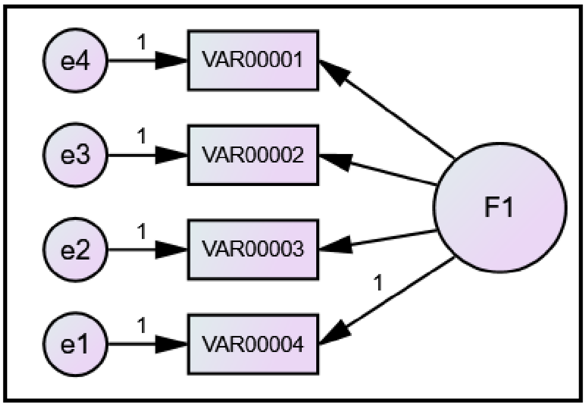

Figure (2): The Confirmatory Factor Analysis of Quality Performance Variable

Source. Developed by the Researcher

We conclude from the previous figure the Model Fit Summary:

Table (3): The Quality Indicators of The Model Fit Summary

Measure	Estimate
CMIN	10.515
DF	2
CMIN/DF	5.146
GFI	0.979
CFI	0.996
TLI	0.987
RMR	0.006

From the previous table:

The Goodness of Fit Index (GFI) is equal to (0.979) and these values close to 1 and a value of 1 indicates a perfect fit.

The Comparative Fit Index (CFI) is equal to (0.996), which falls in the range from 0 to 1 and CFI values close to 1 indicate a very good fit.

The root mean square residual (RMR) is equal to (0.006), RMR values close to 0 indicate a good fit, which the value of (RMR) equal to zero indicates a perfect fit.

The Tucker-Lewis coefficient (TLI) is equal to (0.987), and the typical range of this coefficient is between zero and one. TLI values close to 1 indicate a very good fit.

The results show that:

There is a correlation between the Quality Performance Variable and its items and all the quality indicators of the model achieved an acceptable level some came close to the required level.

Productivity Performance Variable:

The following figure shows the confirmatory factor analysis of Productivity Performance variable:

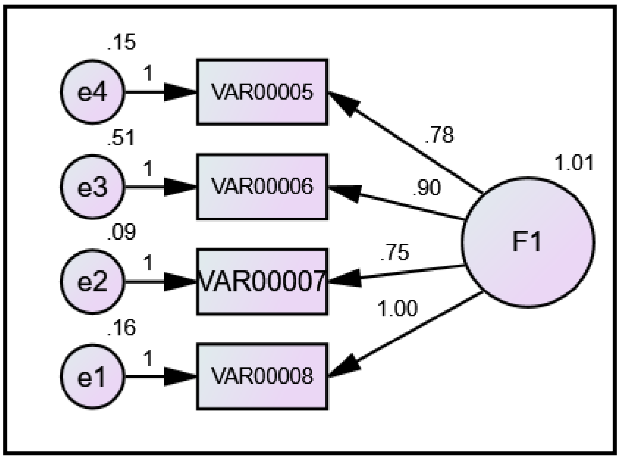

Figure (3): The Confirmatory Factor Analysis of Productivity Performance Variable

Source. Developed by the Researcher

We conclude from the previous figure the Model Fit Summary:

Table (4): The Quality Indicators of The Model Fit Summary

Measure	Estimate
CMIN	10.427
DF	2
CMIN/DF	5.213
GFI	0.980
CFI	0.991
TLI	0.972
RMR	0.015

From the previous table:

The Goodness of Fit Index (GFI) is equal to (0.980) and these values close to 1 and a value of 1 indicates a perfect fit.

The Comparative Fit Index (CFI) is equal to (0.991), which falls in the range from 0 to 1 and CFI values close to 1 indicate a very good fit.

The root mean square residual (RMR) is equal to (0.015), RMR values close to 0 indicate a good fit, which the value of (RMR) equal to zero indicates a perfect fit.

The Tucker-Lewis coefficient (TLI) is equal to (0.972), and the typical range of this coefficient is between zero and one. TLI values close to 1 indicate a very good fit.

The results show that:

There is a correlation between the Productivity Performance Variable and its items and all the quality indicators of the model achieved an acceptable level some came close to the required level.

Cost Reduction Variable:

The following figure shows the confirmatory factor analysis of Cost Reduction variable:

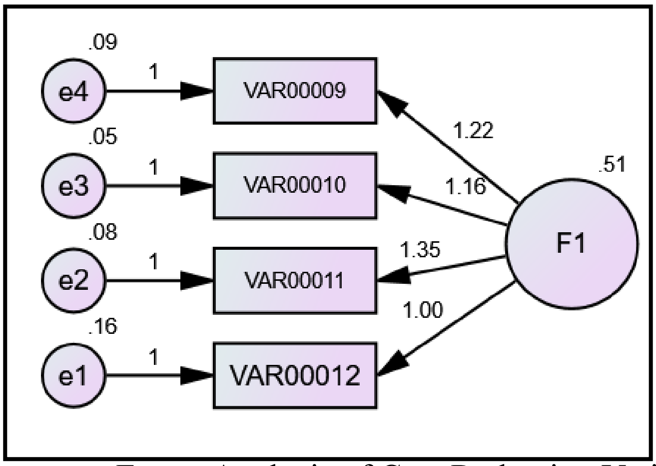

Figure (4): The Confirmatory Factor Analysis of Cost Reduction Variable

Source. Developed by the Research

We conclude from the previous figure the Model Fit Summary:

Table (5): The Quality Indicators of The Model Fit Summary

Measure	Estimate
CMIN	70.126
DF	2
CMIN/DF	35.063
GFI	0.873
CFI	0.951
TLI	0.852
RMR	0.018

From the previous table:

The Goodness of Fit Index (GFI) is equal to (0.873) and these values close to 1 and a value of 1 indicates a perfect fit.

The Comparative Fit Index (CFI) is equal to (0.951), which falls in the range from 0 to 1 and CFI values close to 1 indicate a very good fit.

The root mean square residual (RMR) is equal to (0.018), RMR values close to 0 indicate a good fit, which the value of (RMR) equal to zero indicates a perfect fit.

The Tucker-Lewis coefficient (TLI) is equal to (0.852), and the typical range of this coefficient is between zero and one. TLI values close to 1 indicate a very good fit.

The results show that:

There is a correlation between the Cost Reduction Variable and its items and all the quality indicators of the model achieved an acceptable level some came close to the required level.

<u>6-3 Statistical methods used in data analysis:</u>

The following statistical methods and tests were used :

Conducting descriptive statistics by calculating the arithmetic mean to measure the average opinions of the respondents and calculating the standard deviation (SD) to measure dispersion and weight percentile to measure the Opinions.

Calculating the Pearson correlation coefficient to find out whether there is a relationship between the independent variable dimensions and the dependent variable or not. Note that the correlation coefficient is denoted by the symbol r, and its value is limited between -1 and +1. On the other hand, the sign of the correlation coefficient describes whether the relationship is positive or negative. If the sign is negative (-), this indicates that the relationship between the two variables is negative, that is, an increase in one of them leads to a decrease in the other, and if the sign is positive (+), this indicates that the relationship between the two variables is positive, meaning that an increase in one of them leads to an increase in the other (i.e. the two variables move in the same direction).

Application of Simple Linear Regression and Multiple Linear Regression to study the impact of the independent variable dimensions on the dependent variable.

6-4 Exploring the characteristics of the study sample:

The frequencies and percentage of demographic variables and basic data expressing the study sample of 250 individuals were calculated, in order to explore the characteristics of the study sample (Gender, Age, Educational level, Work Experience, Role Function at Work and Job Level in your organization) as shown in table (6):

Table (6): Frequencies and percentage of demographic variables (N=250)

Source: Developed by the researcher, 2024

Variables	Category	Frequency	Percentage
Gender	Male	161	64.4
	Female	89	35.6
Age group	20 years old	5	2.0
	20 - 30 years old	79	31.6
	30 - 40 years old	83	33.2
	40 - 50 years old	72	28.8
	More than 50 years old	11	4.4
Educational level	Diploma	43	17.2
	Bachelor's Degree	151	60.4
	Master's Degree	45	18.0
	Ph.D. or higher	11	4.4
Work Experience	5 years or less	31	12.4
	6-10 years	55	22.0
	11-15 years	36	14.4
	16-20 years	73	29.2
	21 -25 years	45	18.0

Variables	Category	Frequency	Percentage
	more than 25 years	10	4.0
Role Function at Work	Project Administration	49	19.6
	Project Policies and standards	47	18.8
	Project Management	33	13.2
	Knowledge exchange and education	43	17.2
	Data Assessment and Monitoring	40	16.0
	Information Security	38	15.2
Job Level in your organization	Strategic	8	3.2
	Managerial	6	2.4
	Consultant	37	14.8
	Specialist (Expert)	47	18.8
	Team Lead	22	8.8
	Project Management	101	40.4
	Coordinator Level	20	8.0
	Staff	9	3.6

The frequencies and percentage of organization variables and basic data expressing the study sample of 250 individuals were calculated, in order to explore the characteristics of the study sample as shown in table (7):

Table (7): Frequencies and percentage of organization variables (N=250)

Source: Developed by the researcher

Variables	Category	Frequency	Percentage
How old is your organization?	0 - 2 years	114	45.6
	3 - 6 years	27	10.8
	7 - 15 years	20	8.0
	16 - 50 years	82	32.8
	More than 50 years	7	2.8
Number of empolyees	1 - 10	135	54.0
	10 – 199	90	36.0
	200 - 1.000	7	2.8
	more than 1.000	18	7.2
Financial resources	Optimization/Automation of existing processes	107	42.8
	Optimization/Automation of existing processes	143	57.2
Type of investments is your organization making to transform itself to a digital business	Formed a taskforce	43	17.2
	Hired a consultant	129	51.6
	Appointed a CDO (Chief Digitization Officer)	78	31.2
	Established a data sciences business function	0	0
	Developed a data strategy	0	0
	Hired, or trained, a significant	0	0

Variables	Category	Frequency	Percentage
	number of data scientists		
	Moved one or more of your products/services to the cloud	0	0
	Established one or more new touch points with customers electronically	0	0
How many years has your firm been working towards digitization?	0 - 1 years	12	4.8
	1 - 3 years	106	42.4
	3 - 5 years	102	40.8
	5 - 10 years	28	11.2
	More than 10 years	2	0.8

The frequencies and percentage of Company Name expressing the study sample of 250 individuals were calculated as shown in table (8):

Table (8): Frequencies and percentage of Company Name

Source: Developed by the researcher, 2024

Variables	Frequency	Percent
ADHOC (initial state,no concerted efforts on digitalization strategic imperative)	17	6.8
DEFINED (organization makes digitization a behavior; their goal is to institutionalize the new model)	169	67.6
LEVERAGED (Synergies occur, company involves competencies/people from outside the organization)	59	23.6
OPTIMIZED (New business model is fully internalized; results are repeatable and predictable)	5	2.0
Total	250	100.0

6-5 Conducting descriptive statistics for the study variables:

Descriptive statistics were conducted for the study variables by calculating the arithmetic mean and standard deviation, in order to know the general trend of opinions and the extent of the respondents' awareness of those variables. In addition, the t-test was applied to confirm the general trend of those opinions.

Table (9) presents the mean value, standard deviation and Weight Percentile result at the level of the study variables.

The independent variable (DSC Technologies):

First of all the test examines the existence of the independent variable of (DSC Technologies) as a whole and the results show that the average opinion is (4.12), so the samples agree on its existence at the company with a percentage of (5.01/5 = 82.4%) with SD (0.81).

Accordingly, the (DSC Technologies) variable exists with a percentage of (82.4%).

Table (9): Descriptive statistics for the Robotics Technology variable

Source: Developed by the researcher

Descriptive statistics for the Robotics Technology variable

Source: Developed by the researcher, 2024

Statements	Descriptive Statistics		Degree of Agree	
	Mean	SD	Weight Percentile	Opinion
I though the system was easy to use.	4.32	0.92	86.4	agree
I found the various functions in this system well integrated (the sensors and the robot seemed like a unique system)	4.23	0.96	84.6	agree
I found the robot responding properly to my motion	4.30	0.94	86.0	agree
I felt very confident using the system	3.71	1.42	74.2	agree
I was satisfied by the performances of the system	4.13	1.15	82.6	agree
I found the responding time appropriate	4.19	1.10	83.8	agree
I believe that Robots can assist people in everyday activities	4.25	0.92	85.0	agree
I found the system reliable	3.86	1.30	77.2	agree
Robotics is used to improve production capacity.	4.22	1.12	84.3	agree
Our organization uses or plans to use robotics on a regular basis in the future.	3.79	1.21	75.8	agree
The variable as a whole	4.12	1.05	82.4	agree

Table (9) shows the following:

The average opinion is for answering the statement (I though the system was easy to use) (Agree) with (4.32/5 = 86.4%).

The average opinion is for answering the statement (I found the various functions in this system well integrated (the sensors and the robot seemed like a unique system)) (Agree) with (4.23/5 = 84.6%).

The average opinion is for answering the statement (I found the robot responding properly to my motion) (Agree) with (4.30/5 = 86.0%).

The average opinion is for answering the statement (I felt very confident using the system) (Agree) with (3.71/5 = 74.2%).

The average opinion is for answering the statement (I was satisfied by the performances of the system) (Agree) with (4.13/5 = 82.6%).

The average opinion is for answering the statement (I found the responding time appropriate) (Agree) with (4.19/5 = 83.8%).

The average opinion is for answering the statement (I believe that Robots can assist people in everyday activities) (Agree) with (4.25/5 = 85.0%).

The average opinion is for answering the statement (I found the system reliable) (Agree) with (3.86/5 = 77.2%).

The average opinion is for answering the statement (Robotics is used to improve production capacity) (Agree) with (4.22/5 = 84.3%).

The average opinion is for answering the statement (Our organization uses or plans to use robotics on a regular basis in the future) (Agree) with (3.79/5 = 75.8%).

the results show that existence of the variable of (Robotics Technology) as a whole with average opinion is (4.12), so the sample agree on its existence with a percentage (4.12/5 = 82.4%).

Table (10) Descriptive statistics for the Quality Performance variable

Source: Developed by the researcher, 2024

Statements	Descriptive Statistics		Degree of Agree	
	Mean	SD	Weight Percentile	Opinion
Our organization is able to produce consistent quality products with a low rate of defects.	3.80	1.29	76.1	agree
Our organization operates regular customer satisfaction surveys to monitor our product quality.	3.59	1.39	71.8	agree
Our organization is able to maintain a low number of customer complaints concerning	3.70	1.28	73.9	agree

product quality.				
Our organization is able to supply products based on conformance quality	3.60	1.20	72.1	agree
The variable as a whole	3.80	1.18	76.1	agree

Table (10) shows the following:

The average opinion is for answering the statement (Our organization is able to produce consistent quality products with a low rate of defects) (Agree) with (3.8/7 =76.1%).

The average opinion is for answering the statement (Our organization operates regular customer satisfaction surveys to monitor our product quality) (Agree) with (3.59/5 =71.8%).

The average opinion is for answering the statement (Our organization is able to maintain a low number of customer complaints concerning product quality) (Agree) with (3.70/5 = 73.9%).

The average opinion is for answering the statement (Our organization is able to supply products based on conformance quality) (Agree) with (3.6/5 = 72.1%).

the results show that existence of the variable of (Quality Performance) as a whole with average opinion is (3.80), so the sample agree on its existence with a percentage (3.80/5 = 76.1%).

Table (11) Descriptive statistics for the Productivity Performance variable

Source: Developed by the researcher, 2024

Statements	Descriptive Statistics		Degree of Agree	
	Mean	SD	Weight Percentile	Opinion
Our labor and machine productivity is performing better than in its intended function.	4.58	0.87	91.6	agree
Our organization is able to optimize our production defect/waste to acceptable levels.	4.13	1.15	82.6	agree
Our organization is able to provide short delivery times acceptable to our customers.	4.34	0.81	86.9	agree
Our organization is able to increase capacity	4.03	1.08	80.6	agree

utilization in our production when demand requires it.				
The variable as a whole	4.27	0.89	85.4	agree

Table (11) shows the following:

The average opinion is for answering the statement (Our labor and machine productivity is performing better than in its intended function) (Agree) with (4.58/5 = 91.6%).

The average opinion is for answering the statement (Our organization is able to optimize our production defect/waste to acceptable levels) (Agree) with (4.13/5 = 82.6%).

The average opinion is for answering the statement (Our organization is able to provide short delivery times acceptable to our customers) (Agree) with (4.34/5 = 86.9).

The average opinion is for answering the statement (Our organization is able to increase capacity utilization in our production when demand requires it) (Agree) with (4.03/5 = 80.6%).

The results show that existence of the variable of (Productivity Performance) as a whole with average opinion is (4.27), so the samples agree on its existence at the company with a percentage (4.27/5 = 85.4%).

Table (12) Descriptive statistics for the Cost Reduction variable

Source: Developed by the researcher, 2024

Statements	Descriptive Statistics		Degree of Agree	
	Mean	SD	Weight Percentile	Opinion
Our organization is able e to manufacture products at competitive prices while maintaining a profitable operational performance.	4.50	0.92	89.9	agree
Our organization is able to produce products from a low inventory of raw materials thereby minimizing production costs.	4.43	0.86	88.6	agree
Overall, our logistics costs (including distribution, transportation, and handling costs) can be reduced year on year through our supply chain management.	4.07	1.01	81.4	agree
The reductions in cost achieved are considerably better value than expected.	4.46	0.82	89.1	agree
The variable as a whole	4.37	0.86	87.3	agree

Table (12) shows the following:

The average opinion is for answering the statement (Our organization is able e to manufacture products at competitive prices while maintaining a profitable operational performance) (Agree) with (4.50/5 = 89.9%).

The average opinion is for answering the statement (Our organization is able to produce products from a low inventory of raw materials thereby minimizing production costs) (Agree) with (4.43/5 = 88.6%).

The average opinion is for answering the statement (Overall, our logistics costs (including distribution, transportation, and handling costs) can be reduced year on year through our supply chain management) (Agree) with (4.07/5 = 81.4).

The average opinion is for answering the statement (The reductions in cost achieved are considerably better value than expected) (Agree) with (4.46/5 = 89.1%).

The results show that existence of the variable of (Cost Reduction) as a whole with average opinion is (4.37), so the samples agree on its existence at the company with a percentage (4.37/5 = 87.3%).

6-5 Testing the study hypothesis:

In this section, a set of statistical analyses was conducted to test the study's main hypothesis which is:

There is a positive relationship between DSC technology of Robotics and the organizations' operational performance.

To test this hypothesis, it was relied on calculating the Pearson correlation coefficient to find out whether there is a relationship (correlation) between the Robotics Technology and Organizations' Operational Performance or not.

Then simple linear regression analysis was applied to study the impact of Robotics technology on the Organizations' Operational Performance.

• The following are the statistical analysis that were carried out to test the hypothesis:

Table (13) shows the values of the regression coefficients, the result of the t-test to ascertain the significance of the independent variable that constitutes the model, in addition to the result of the (coefficient of correlation (r)), the (coefficient of determination (R^2), and the (Standard Error of the Estimate (SE), and (F-test) result on the ANOVA table to as certain the significance of the regression model as a whole.

Table (13): Summary of regression models impact of DSC technology of Robotics on Organizations' Operational Performance

Source: Developed by the researcher, 2024

Variables	Regression Coefficients		t-test		(r)	(R^2)	ANOVA	
	B	SE	t-test value	p–value			F-test value	p–value
Constant	0.396	0.037	10.840	0.000	0.989	0.978	11239.236	0.000
Robotics technology	0.910	0.009	106.015	0.000				

It is clear from Table (13) that:

There is a statistically significant impact of the Interactional Justice as a whole (X3) on Organizations' Operational Performance (Y) with a level of significance of 5%, where the probability value of the t-test is less than the value of the level of significance (p-value = 0.000 < α = 0.05). Moreover, it was found that the regression model is a statistically significant model with a level of significance of 5%, where the probability value of the F-test is less than the level of significance (p-value = 0.000 < α = 0.05). The Interactional Justice is related with Organizations' Operational Performance with a percentage of (98.9%), where the value of the correlation coefficient is (0.989).

It is also noted that the Interactional Justice in impact positively on Organizations' Operational Performance with a percentage of approximately (97.8%) where the value of the determination coefficient is (0.978) while the remaining part (2.2%) may be due to random error or other factors that could have an impact on and were not covered in the current study.

As a final conclusion, it was found that: There is a positive relationship between DSC technology of Robotics and the organizations' operational performance, therefore the hypothesis of the study was accepted.

7- Conclusion:

The following table summarizes the results of the statistical analysis in relation to the objectives of the study:

Source: Developed by the researcher, 2024

Objective	Results
1-To identify the existence of DSC Technology	The results proved that The initial dimension Robotics Technology exists with a percentage of (82.4%)
2- To decide whether the existence of the Organizations' Operational Performance	The results proved that there is existence of the as Organizations' Operational Performance a whole system applied with a percentage of (82.9%)
	Concerning the sub dimensions that are constituting the Organizations' Operational Performance:
	The first dimension Quality Performance exists with a percentage of (76.1%)
	The second dimension Productivity Performance with a percentage of (85.4%)
	The third dimension Cost Reduction exists with a

Objective	Results
	percentage of (87.3%)
3- To investigate the impact of DSC Technology on Organizations' Operational Performance.	There is a relationship between the initial dimension of the DSC Technologies (Robotics) and Organizations' Operational Performance.
	The results of the regression analysis proved that the DSC Technologies has a significant impact on Organizations' Operational Performance as a whole in with a percentage of (94.6%)
	The result of the Multiple regression analysis proved that the DSC Technologies initial dimension (Robotics) has a significant impact on Organizations' Operational Performance with a percentage of (97.9%)
4- To investigate the relationship of DSC Technology dimensions and Organizations' Operational Performance.	The results of the Pearson correlation analysis proved that a positive relationship between Robotics technology and the organizations' operational Performance as a whole in with a percentage of (98.9%)
5- To investigate the impact of DSC Technology dimensions on Organizations' Operational Performance.	The results of the regression analysis proved that the Robotics technology has a significant impact on optimism in with a percentage of (97.8%)

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