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A causal model to assess the influence of supply chain 4.0 on Moroccan companies' performance

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ABSTRACT

Although supply chain 4.0 (SC 4.0) has been widely adopted by major industries globally, particularly in developed countries, Moroccan industries, including key sectors like automotive and aeronautical, are just beginning to give this concept the attention it deserves, therefore, the examination of the impact of this new concept on the companies' performance has not been presented in the literature review. This paper presents a conceptual model used to evaluate the impact of the SC 4.0 levers (purchase and supply, production, storage and distribution, and sales and after-sales) on companies' financial and organizational performance using the statistical package for the social sciences (SPSS) version 26.0, the goal is to investigate the relationship between the SC 4.0 levers as a mean construct in one hand, and the other hand, financial and organizational performance as results constructs, the findings in this research paper confirm the significant and positive relationship between these constructs, aligning with what was cited in the literature review.

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1. INTRODUCTION

In the current corporate environment, supply chain specialists have made digitizing processes a priority [1], [2]. Industry 4.0 aims to digitally revolutionize traditional supply systems [3]. Supply chain digitalization, also known as supply chain 4.0 (SC 4.0), is the driving force behind the incorporation of digital technologies like big data, blockchain, cloud computing, internet of things (IoT), and artificial intelligence into supply chain operations [4]–[6]. Big worldwide manufacturing companies have been adopting various Industry 4.0 technologies. According to Pandey *et al*. [2], efficiency was cited by 98% of supply chain experts as the primary justification for Industry 4.0 investment [2], since supply chains operate better thanks to the enhanced analytical capabilities brought about by these technologies [7]. Increased demand and manufacturing flexibility, product diversification, shortened lead times, and improved market responsiveness are further advantages of Industry 4.0 [8], [9].

Despite its importance, in Morocco, research on SC 4.0 remains relatively less advanced. Moroccan firms operate in an environment defined by an increasingly strong competitive offer, rising demands, and higher customer expectations. To thrive and maintain their competitiveness, these companies must introduce concepts like SC 4.0 to boost the image of their service while addressing the demands for flexibility, speed, and adaptability. By performing a bibliometric analysis and conducting a systematic review of literature, Andaloussi [10], discovered that transitioning from manual to digital processes in supply chain management

enhances efficiency, improves performance, and increases transparency, making identifying and solving issues within supply chain management easier.

Eslami *et al.* [11] conducted a cross-sectional survey in 2020, collecting data from 274 Swedish manufacturing companies, using the ESMaker cloud-based tool to investigate the link between supply chain operations and financial performance. Their work contributed to enhancing the existing theoretical understanding of the interconnections between supply chains and how they contribute to achieving a financial competitive advantage. Furthermore, the implementation of Industry 4.0 digital technologies enables a seamless flow of real-time information, which, when applied effectively throughout the supply chain, can significantly boost efficiency and responsiveness to market fluctuations.

Fatorachian and Kazemi [7] explained that their study, grounded in an exploratory and systematic literature review, seeks to examine how Industry 4.0's advanced technologies can enhance supply chain performance and provide a foundation for developing new supply chain theories. Conversely, Eslami *et al.* [11] pointed out that one limitation of their research is its focus on Swedish manufacturing firms, meaning the findings may not be applicable to other sectors or countries. However, these researchers have laid the groundwork for further expansion of our study.

Despite prior studies highlighting the favorable impact of supply chain digitalization on performance and operations, there is a noticeable gap in research regarding the effect of SC 4.0 on financial and operational performance, especially within Morocco's automotive and aeronautic industries. This study aims to assess whether digitalizing the supply chain impacts these specific performance indicators. Its originality lies in offering a comprehensive and integrated approach to applying Industry 4.0 technological innovations in the supply chain. Furthermore, the study adopts an analytical perspective, using systems theory, to inspect the effects of SC 4.0 on both the financial and organizational performance of firms.

The structure of the remainder sections in this research paper is outlined as follows: we begin with a literature review, which is followed by a description of the problem at hand. The central question we explore is the extent to which SC 4.0 positively affects the performance of automotive and aerospace firms in Morocco. To address this question, we quantitatively modeled the relationship using a linear equation through the linear regression method, with the assistance of the statistical package for the social sciences (SPSS) software. After this, we introduce the model and hypotheses of our study, analyze the findings, and conclude the paper by summarizing the key results, acknowledging some research limitations, and proposing areas for future exploration.

2. LITERATURE REVIEW

Considering what was cited before, Moroccan manufacturing companies are still in need of how to put in place SC 4.0 and understand its benefits on their performance, concept is defined. According to Makris *et al.* [12], a supply chain that is based on digital technologies, such as web-enabled technology, the IoT, and big data analytics (BDA), requires tight cooperation between various stakeholders (such as suppliers and customers) [12].

2.1. Supply chain 4.0

A supply chain is a group of organizations, systems, and procedures that work together to create services and products that are valuable. Ultimately delivering them to end users. These chains connect nations, physical distribution networks, and transportation systems, collectively forming a worldwide network. Supply chains involve the movement of materials, products, and information both internally and across organizations [13]–[15].

In order to enhance existing supply chain systems, SC 4.0 calls for the integration of production and communication technologies. These technologies allow for location-independent operations, seamless integration, a variety of automated services, and responsiveness to client requests and needs [14]. Smart SC 4.0 relies on technology to acquire information about the flow of materials, subsequently employing this data for monitoring, control, and additional applications. The level of intelligence is contingent upon the specific applications and methods utilized [16]–[18].

SC 4.0 involves implementing Industry 4.0 technologies such as the IoT, cyber security (CS), and radio-frequency identification (RFID) in conventional supply chains. This transformation promotes a move away from the traditional linear and static model of supply chains ("supplier, production, distribution, and consumer") to a more integrated and dynamic model. The objective is to address various challenges, gain a competitive advantage, and improve overall firm performance [19].

2.2. Performance of firms

Traditionally, performance has been perceived as a singular dimension, primarily measured by profit, largely due to the predominant influence of owners over the decision-making process. From this standpoint, the assessment of performance primarily emphasizes shareholder value creation centers [20]. The performance of a company can be primarily classified into two main groups: financial measures and non-financial measures [21]. Researchers have employed various terminology, including efficiency and financial parameters, short- and long-term measurements, and financial and operational performance metrics. Short-term metrics typically focus on financial returns, whereas long-term metrics often center on non-financial returns. Broadly speaking, financial performance indicators encompass variables that typically reflect a firm's profitability, while non-financial indicators comprise variables not measured by financial systems [20], [22].

2.2.1. Financial performance

Naz *et al*. [23] describe financial performance as the assessment of a company's financial well-being over a particular timeframe. In other words, an organization's capacity and readiness to fulfill its long-term financial liabilities, as well as its commitment to delivering services in the near term, are all included in its financial success [23]. In a more extensive perspective, financial performance denotes the extent to which financial objectives are achieved [20], [24].

Financial performance refers to a collection of financial indicators utilized to assess whether a company's strategy, both in intention and execution, contributes to the enhancement of its financial standing. Typically, a company's financial objectives encompass aspects like profitability, sales, and cost reduction. These indicators must be tailored to the specific circumstances of the company, considering factors such as its reality, context, industry sector, competitive landscape, and the strategy adopted by each business unit. Consequently, each unit is tasked with selecting indicators that are most pertinent to its context [25].

2.2.2. Organizational performance

Organizational performance denotes the capacity of a company to accomplish its objectives and optimize outcomes. In the contemporary workplace, organizational performance can be encapsulated as the company's proficiency in attaining objectives amidst continual change [26], [27]. Organizational performance is related to the efficiency of the company's framework in achieving its goals, emphasizing the effective realization of objectives. It assesses the firm's capacity to implement efficient processes in order to meet both operational and strategic projections [20], [28].

3. RESEARCH METHOD

According to Elkazini [29], linear regression represents a type of regression analysis that describes the connection between a dependent variable and one or more independent variables by employing a least-squares function, commonly known as a linear regression equation. Regression models serve to express relationships between variables by fitting a line to the observed data, allowing for the estimation of how the dependent variable responds to changes in the independent variable(s). When there is a single independent variable, this is called simple linear regression, while having multiple independent variables is known as multiple linear regression. In the results, a p-value below 0.05 indicates a significant relationship between the independent and dependent variables, and vice versa. The regression coefficient is a variable in the regression equation that assesses the effect of the independent variable on the dependent variable.

As stated by Rani *et al.* [30], ordinary least squares regression is frequently called linear regression, whether it is simple or multiple, depending on the number of explanatory variables. For a model with p explanatory variables, the ordinary least squares regression model can be expressed as (1).

$$Y = \beta 0 + \Sigma j = 1..p\ \beta jXj + \varepsilon \quad (1)$$

Where Y represents the dependent variable, β0 is the model's intercept, Xj denotes the j_{th} explanatory variable in the model (where j ranges from 1 to p), and ε is the random error with an expected value of 0 and a variance of σ^2. In the scenario where there are n observations, the predicted value of the dependent variable Y for the i_{th} observation can be expressed as (2).

$$yi = \beta 0 + \Sigma j = 1..p\ \beta jXij \quad (2)$$

The ordinary least squares method involves minimizing the sum of the squared differences between the observed and predicted values. This minimization results in the following estimators for the model parameters as in (3).

$$[\beta = (X'DX) - 1\ X'\ Dy\ \sigma^2 = 1/(W - p*)\ \Sigma i = 1..n\ wi(yi - yi)] \quad (3)$$

Where β represents the vector of estimators for the βi parameters, X is the matrix of explanatory variables accompanied by a vector of 1s, y is the vector of the n observed values of the dependent variable, p* is the number of explanatory variables, with an additional 1 included if the intercept is not fixed, wi is the weight of the i_{th} observation, W denotes the sum of the wi weights, and D is a matrix with the wi weights along its diagonal. The vector of predicted values can be expressed as (4).

$$y = X\ (X'\ DX) - 1\ X'Dy \quad (4)$$

This study aims to assess and confirm a conceptual model developed to quantify the effects of: i) purchase and supply (PS) on financial and organizational performance, ii) production (PR) on financial and organizational performance, iii) storage and distribution (SD) on financial and organizational performance, and iv) sales and after-sales (SAS) on financial and organizational performance. Applying linear regression through SPSS software version 26.0, this study utilized a sample of 95 questionnaires distributed in both face-to-face interviews and online Google Forms. The survey targeted directors, industrial leaders, and supply chain managers within Moroccan automotive and aeronautic companies.

This method has been employed by numerous researchers to examine the relationships between variables, particularly in recent years. Notably, Rani *et al.* [30] investigated the effect of corporate social responsibility on development sectors in India using ordinary least squares. In another study, Elkazini [29], utilized linear regression with SPSS software to explore the effect of Industry 4.0 adoption levels on supply chain agility and resilience.

3.1. Definition of our model's constructs

The main hypothesis of our study is that SC 4.0 positively influences both the financial and organizational performance of Moroccan automotive and aeronautic companies. To validate this hypothesis, we developed a research model comprising the following two main constructs: i) SC 4.0 and ii) financial and organizational performance.

3.1.1. First research construct: supply chain 4.0

A supply chain consists of a network of organizations and systems working together to produce and deliver valuable goods and services to end users. It involves the four levers cited as follows. The four levers present the latent variables of our first construct: PS, PR, SD, and SAS.

3.1.2. Second research construct: Financial and organizational performance of the firms

Financial performance measures a company's financial health. Organizational performance reflects its ability to achieve goals and adapt to change effectively. These two types of performances present the core elements of our second research construct: i) financial performance and ii) organizational performance.

3.2. Presentation of the research model

Our model is structured around five criteria, categorized into two families: four criteria pertain to the methods (SC 4.0), while the remaining criteria are associated with the outcomes (financial and organizational performance) as shown in Figure 1. We assume that the criteria of results and the criterion of means are causally related. Stated differently, the methods employed are the reasons behind the outcomes obtained. It should be mentioned that a hypothesis has been developed for each causal relationship. Four theories have been developed in light of the four causal links found in the suggested conceptual model.

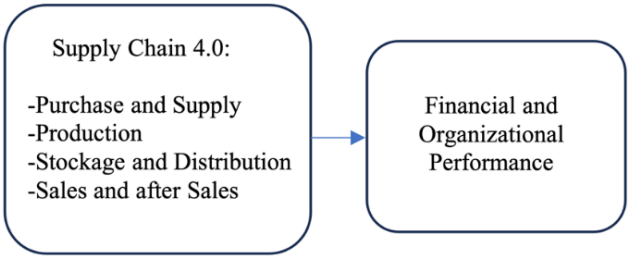

Figure 1. Primary conceptual model

We posit a causal relationship between the methods criteria and the outcomes criteria. In essence, the established means serve as the causal factors for the observed outcomes. It is interesting to notice that a hypothesis has been developed for every causal link. Eight hypotheses have been put out in light of the conceptual model's eight causal links, Figure 2 demonstrates our global conceptual model, and Table 1 presents the constructs and the codes used for each variable latent.

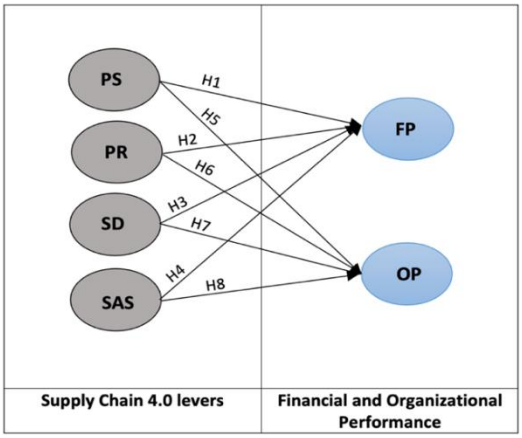

Figure 2. Precise conceptual model

Table 1. Displaying the codes employed in the causal model

Constructs of the proposed model	Code	Components
Supply chain 4.0	PS	Purchase and supply
	PR	Production
	SD	Storage and distribution
	SAS	Sales and after-sales
Financial and organizational performance	FP	Financial performance
	OP	Organizational performance

3.3. Stated hypothesis

From our model, eight hypotheses can be derived. Each represents a correlation between a specific latent variable from construct 1 and another latent variable from construct 2. Our study aims to confirm or refute these eight hypotheses as shown in Table 2.

Table 2. Hypotheses list

Hypothesis N°	Causal Relationship	Hypothesis generated
H1	PS ⟹ FP	We hypothesize that PS positively influences FP
H2	PR ⟹ FP	We hypothesize that PR positively influences FP
H3	SD ⟹ FP	We hypothesize that SD positively influences FP
H4	SAS ⟹ FP	We hypothesize that SAS positively influences FP
H5	PS ⟹ OP	We hypothesize that PS positively influences OP
H6	PR ⟹ OP	We hypothesize that PR positively influences OP
H7	SD ⟹ OP	We hypothesize that SD positively influences OP
H8	SAS ⟹ OP	We hypothesize that SAS positively influences OP

3.4. Development of the methodological framework for research

For this particular study, we intend to collect primary data firsthand by engaging with selected individuals. This will involve administering a structured questionnaire, distributed either in hard copy or through a Google Forms link, to general managers, industrial engineers, and supply chain managers within the automotive and aeronautic industries in Morocco. Data collection was ultimately conducted in November 2023, following the distribution of the survey to 190 corporations, 140 in the automotive sector and 50 in the aeronautic sector, via the LinkedIn platform in August 2023. Therefore, the overall response rate stands at 57.36% falling within the moderate range, therefore the sample used in this study is considered to be representative, Table 3 demonstrates the demographic profile of the participating firms in our study.

Table 3. Demographic profile of the involved firms

Characteristics	Groups	Occurrence	Percentage
Area of company activity	Manufacturing	52	54.73
	Assembly industry	19	20
	Wiring sector	11	11.60
	Service	7	7.36
	Others	6	6.31
Year of establishment	<11 years	38	40
	11 years – 21 years	24	25.26
	>20 years	33	34.74
Certification ISO 9001	Yes	87	91.5
	No	8	8.5
Customers	<11	26	27.35
	11 – 151	49	51.60
	>150	20	21.05

3.5. Questionnaire steps

The structure of the questionnaire utilized in this study is as follows: after briefly explaining the survey's goal and how it relates to our findings, we go directly to the first section, which contains information about the interviewed employees, and the firms' information, the second part of our questionnaire covered our conceptual model constructs. The format of the questionnaire employed in this study is outlined as follows: after providing a concise overview of the survey's objective and its connection to our findings, we proceed directly to the initial section. This section encompasses details about the interviewed employees and the firms' information. The subsequent part of our questionnaire addresses the constructs outlined in our conceptual model, these constructs are (SC 4.0 and financial and organizational performance) with a number of 51 items (30 for SC 4.0, 21 for financial and organizational performance), these items were employed to assess the specified constructs, using a six-Likert scale from ''0=Abs/No to 6=very high'' [28]. We employ Churchill's (1979) well-established paradigm as the foundation for implementing our measurement instrument. Many researchers commonly adopt this paradigm to formulate their measurement scales [31].

The paradigm is explained as follows: in the pursuit of constructing a robust and comprehensive measurement tool, the initial step involves specifying the domain of the construct through an exhaustive literature search. This process lays the foundation for the subsequent stages, ensuring a thorough understanding of existing knowledge and conceptual boundaries. Following this, a diverse sample of items is generated through a multifaceted approach, encompassing literature reviews, experience surveys, illustrative examples, critical incidents, and focus group discussions. With the items in place, data collection ensues, capturing a wide array of perspectives and experiences related to the construct under consideration. The refinement of the measurement instrument is then undertaken through the application of statistical techniques such as coefficient alpha and factor analysis, thereby purifying the measure and enhancing its reliability. Further assurance of reliability is sought through additional data collection and assessment using coefficient alpha and split-half reliability. Concurrently, the validity of the instrument is rigorously evaluated using the multitrait-multimethod matrix and criterion validity. Finally, the development of norms completes the process, employing averages and other statistical measures to summarize the distribution of scores, providing a valuable benchmark for interpreting results and facilitating meaningful comparisons [32].

4. RESULTS AND DISCUSSION

4.1. Reliability test

The survey instrument's reliability was evaluated using Cronbach's Alpha. The results in Table 4 suggest that all the conditions and constructs utilized in this study are valid and reliable. As their values surpass the minimum criterion of 0.7 [33], [34].

Table 4. Overview of the analysis assessing the reliability and validity of the two constructs

Constructs	Variables	Code	Number of items	Cronbach's Alpha α
Supply Chain 4.0	Purchase and sale	PS	7	0.958
	Production	PR	8	0.985
	Storage and distribution	SD	7	0.965
	Sales and after-sales	SAS	8	0.977
Financial and Organizational Performance	Financial performance	FP	8	0.964
	Organizational performance	OP	13	0.974

4.2. Measuring the relationship between supply chain 4.0 (PS, PR, SD, SAS) and financial performance

4.2.1. Overview of the overall model: supply chain 4.0 Levers (PS, PR, SD, SAS)-financial performance

As per Table 5, it is evident that the correlation between the levers of SC 4.0 criteria and financial performance is strongly positive (R=0.739). The SC 4.0 levers account for 54.6% of the variance in financial performance (adjusted R-squared=0.546). In summary, the model is deemed valid, as indicated by its significance level of 0.000, which is below the 5% threshold (Table 6).

Table 5. A summary of the model (SC 4.0-financial performance)

Model	R	R-squared	Adjusted R-Squared	Standard error of estimation
Supply Chain 4.0-financial performance	0.739	0.546	0.525	0.68888095

i) Predicted (Independent) values: PS, PR, SD, SAS
ii) Concerning the regression at the origin (a model without a constant term), it represents the percentage of the dependent variable's validity that is centered around the regression's origin. In models with a constant, this metric cannot be directly compared to R-squared.
iii) Dependent variable: FP
iv) Origin-based linear regression

Table 6. Analysis of variance (SC 4.0-financial performance)

Model	Sum of squares	DDL	Average Squared	D	Sig.
Regression	51.290	4	12.822	27.020	0.000
Residual	42.710	90	0.475		
Total	94.000	94			

i) Dependent variable: FP
ii) Origin-based linear regression
iii) Predicted values: PS, PR, SD, SAS
iv) The total sum of squares is unadjusted for the constant since the constant is zero in the regression at the origin.

4.2.2. Regression equation: supply chain 4.0 levers (supply chain 4.0)–financial performance

The linear regression equation can be formulated as presented in Table 7. The causal relationship between SD and financial performance as well as the relationship between SAS and financial performance are statistically significant (P-value <5%). However, this does not apply to PS and PR which are not valid, as their significance is above 5%. Notably, the t-student value exceeds |2.775| (|1.960|), indicating the presence of significant parameters within the 1% range (5%) [35].

$$FP = 0.100\,PS + 0.110\,PR + 0.290\,SD + 0.314\,SAS \quad (5)$$

Table 7. Criteria coefficients (SC 4.0-financial performance)

Model	Unstandardized coefficients		Standardized coefficients	t-student	Sig. (p-value)
	A	Standard error	Beta		
PS	0.100	0.109	0.100	0.915	0.363
PR	0.110	0.134	0.110	0.827	0.410
SD	0.290	0.129	0.290	2.252	0.027
SAS	0.314	0.125	0.314	2.503	0.014

4.3. Measuring the relationship between supply chain 4.0 levers and organizational performance

4.3.1. Overview of the overall model: supply chain 4.0 levers (PS, PR, SD, SAS)–organizational performance

As indicated in Table 8, the correlation between the levers of SC 4.0 criteria and organizational performance is strongly positive (R=0.681). The SC 4.0 levers account for 46.3% of the variance in organizational performance (adjusted R-squared=0.463). In summary, the model is considered valid, given its significance level of 0.000, which is below the 5% margin (Table 9).

Table 8. An overview of the model (SC 4.0-organizational performance)

Model	R	R-squared	Adjusted R-Squared	Standard error of estimation
Supply Chain 4.0-organizational performance	0.681	0.463	0.439	0.74877021

i) Predicted (Independent) values: PS, PR, SD, SAS
ii) Concerning the regression at the origin (a model without a constant term), it represents the percentage of the dependent variable's validity that is centered around the regression's origin. In models with a constant, this metric cannot be directly compared to R-squared.
iii) Dependent variable: OP
iv) Origin-based linear regression

Table 9. Analysis of variance (SC 4.0-organizational performance)

Model	Sum of squares	DDL	Average Squared	D	Sig.
Regression	43.541	4	10.885	19.415	0.000
Residual	50.459	90	0.561		
Total	94.000	94			

i) Dependent variable: OP
ii) Origin-based linear regression
iii) Predicted values: PS, PR, SD, SAS
iv) The total sum of squares is unadjusted for the constant since the constant is zero in the regression at the origin.

4.3.2. Regression equation: supply chain 4.0 levers–organizational performance

The linear regression equation can be expressed as shown in Table 10, please observe that the significances for PR, SD, and SAS are not valid (sig. >5%). However, this does not apply to PS. Consequently, the relationship between organizational performance and PS is deemed significant.

$$OP = 0.445\,PS + 0.130\,PR + 0.083\,SD + 0.089\,SAS \quad (6)$$

Table 10. Criteria coefficients (SC 4.0-organizational performance)

Model	Unstandardized coefficients		Standardized coefficients	t-student	Sig. (p-value)
	A	Standard error	Beta		
PS	0.445	0.119	0.445	3.751	0.000
PR	0.130	0.145	0.130	0.894	0.374
SD	0.083	0.140	0.083	0.592	0.555
SAS	0.089	0.136	0.089	0.657	0.513

4.4. Overall model incorporating the results and findings derived from the hypothesis testing

Each causal relationship corresponds to a derived hypothesis. We have formulated our derived hypotheses, each representing one of the four causal links. The outcomes of the hypothesis test and the overall model are presented in Figure 3 and Table 11.

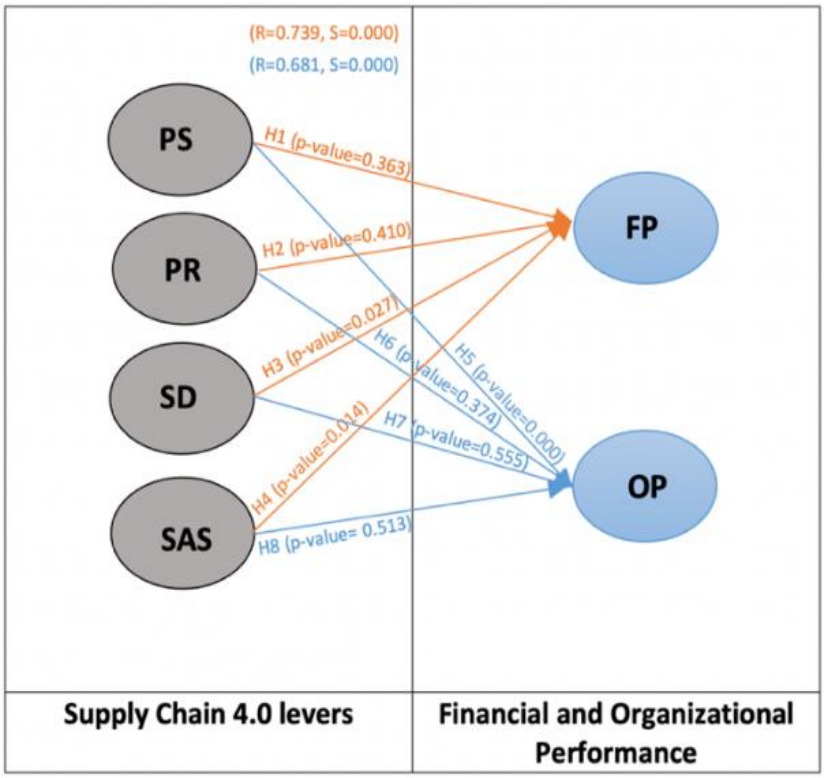

Figure 3. The overall model with the results of hypotheses

Table 11. Hypothesis test results

Hypothesis N°	Causal Relationship	Results
H1	PS → FP	Invalid
H2	PR → FP	Invalid
H3	SD → FP	Valid
H4	SAS → FP	Valid
H5	PS → OP	Valid
H6	PR → OP	Invalid
H7	SD → OP	Invalid
H8	SAS → OP	Invalid

4.5. Discussion and interpretation

Nowadays, companies search to enhance their performance by implementing novel concepts like SC 4.0, which according to certain authors, involves the incorporation of crucial business activities spanning from end-users to the initial suppliers, including the delivery of goods, services, and data that increase customer value and improve the functioning of organizations [36]. In this study we seek to determine the correlation between SC 4.0 and the financial and organizational performance of firms, according to Eslami *et al*. [11] there is a positive connection between SC 4.0 and financial performance, proving that increasing delivery performance and improving firms' market and sales will lead to better profitability [11], [37]. Gunasekaran *et al.* [39] stated that according to Choudhury *et al.* [38] a company's supply chain performance can improve market share and financial performance by lowering costs [38], [39]. Therefore, in accordance with these findings our findings reveal a notably strong and positive relationship between SC 4.0 levers and financial performance (R=0.739; p-value=0.000), especially the 'SD' lever and 'SAS' lever, while the relationship between 'PS' in addition to 'PR' levers with the financial performance is considered invalid, we can interpret from this results that even if the whole SC 4.0 have a positive impact on financial performance, its 'PR' and 'PS' does not seem to have that much influence on it.

According to the statistical analysis established by Kurdi *et al*. [27] the hypothesis results revealed a significant correlation between SC 4.0 and organizational performance [27]. According to Wamba *et al.* [41], written observed that organizational performance is positively impacted by supply chain productivity [40], [41]. Furthermore, considering the present paper's analysis the findings show, certainly, a significant and positive relationship between SC 4.0 and organizational performance (R=0.681; p-value=0.000). Yet, the last three hypotheses (H6: PR positively influences organizational performance, H7: SD positively influences organizational performance, H8: SAS positively influences organizational performance) are considered invalid, we can conclude from these results that PS has the most significant impact on organizational performance more than any lever of SC 4.0, which aligns with some authors suggesting that SC 4.0 incorporates crucial business activities from the primary suppliers, delivering goods, services, and information that enhance consumer value and boost organizational performance [27], [36].

Ivanov *et al.* [9], noted that the expected influence of SC 4.0 over the coming two to three years is significant, with expectations of up to a 30% reduction in operational costs, a 75% decrease in lost sales, and a reduction in inventories by as much as 75%. Another crucial aspect is the anticipated decrease in forecasting errors. With the help of predictive analytics in demand planning, forecasting inaccuracies are projected to decline by 30-50%. Overall, substantial improvements are expected over the next decade. Additionally, industrial component producers are poised to attain some of the most significant productivity gains, estimated between 20-30%, while automotive firms can anticipate growth rates of 10-20%. Therefore, we contend that by adopting SC 4.0, companies can enhance their operational performance. This aligns with Eslami *et al.* [11], who indicated that integrating such digital technologies enables firms to realize benefits beyond just outperforming their competitors from an operational perspective, as previously highlighted by [42], [43].

5. CONCLUSION

By implementing SC 4.0 and overcoming its obstacles, Moroccan firms in the automotive and aeronautics industries have the potential to significantly improve their performance. The objective of this research was to affirm this hypothesis and assess if there is a relation between these concepts. Our exploratory study revealed a correlation between SC 4.0 and financial performance, with SD and SAS exerting the most significant influence. In contrast, PS and PR do not show a strong relationship with financial performance. However, PS significantly affects organizational performance, while other SC 4.0 elements show weaker correlations. Previous studies have explored the impact of SC 4.0 on operational performance, demonstrating that it can enhance this aspect. The results of our study highlighted several important managerial implications. Firstly, with market demands for supply chain efficiency at an all-time

high, companies need to concentrate on enhancing their supply chain to help them achieve their financial and operational objectives. Secondly, our research indicates that a firm's organizational and financial performance is partially enhanced through supply chain levers. Nevertheless, as numerous manufacturing companies have yet to fully understand the various advantages of SC 4.0, managers need to acquire knowledge of how Industry 4.0 technologies are implemented within SC 4.0. Additionally, based on our findings, to enhance financial and organizational performances managers need to allocate resources to SC 4.0 and focus on the cultivation and enhancement of skills among all employees, enabling their companies to respond rapidly to shifts in market needs. This digitalization improves the ability to track and monitor supply chain processes, facilitate real-time information exchange, and offer greater amounts of information for analysis and decision-making.

6. LIMITATIONS AND PERSPECTIVES

Our research indicates that certain levers of SC 4.0 positively impact financial performance, while other levers, such as purchasing and supply, have a positive effect on the organizational performance of Moroccan automotive and aeronautic companies. Future studies could explore the impact of SC 4.0 on the commercial, social, or societal performance of these companies, or extend the analysis to other sectors such as agriculture or healthcare. Another future scope of our research is to assess the level of Industry 5.0 and SC 5.0 implementation in Morocco or other developing countries that have already adopted these concepts, to provide a foundation for future research.

A key factor in moving the industry from 4.0 to 5.0 is higher education in industrial science, which focuses on workforce development specific to the manufacturing period. To achieve this change, engineering departments must work together. Even though this study contributes meaningfully both theoretically and practically, there are still unanswered questions that call for more investigation. This study provides a theoretical framework and eight claims that may be investigated quantitatively in the future. It's crucial to remember that this study concentrated on particular industries and a single nation, recognizing that the adoption, creation, and application of systems vary between sectors and nations. As such, the findings have global applicability and can be repeated in other contexts, especially in developing nations, with implications for SC 5.0 adoption.

This research paves the way for new perspectives in statistical modeling, emphasizing the significance of the statistical approach and the potential of alternative methods like partial least squares (PLS) using linear structural relationships (LISREL). However, these approaches require a larger sample of companies for more accurate results. Additionally, it is suggested that using Google Forms to collect data presents certain limitations, making it crucial to explore alternative data collection methods.

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