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Operational Impact of Information System Integration on Cost Efficiency, Inventory Control, and Timeliness in Citrus Supply Chain Dynamics

Impact Opérationnel de des Systèmes d'Information Intégrés sur l'Efficacité des Coûts, la Gestion des Stocks, et la Rapidité dans la Chaîne Logistique Agrumicole

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Abstract:

The present research investigates information systems adoption in Moroccan Citrus Packing Stations (CPS) and its operational implications for supply chain dynamics amid the challenging climatic conditions of the 2022-2023. This study focuses on examining the impact of integrated information systems (IS) on cost efficiency, inventory control, and delivery timeliness in the citrus sector, a vital component of Morocco's national economy. Adopting a sequential exploratory design, the initial qualitative phase entailed five semi-structured interviews with key personnel in CPS; which enabled the creation of survey items for the subsequent quantitative analysis, where a questionnaire was distributed to all 50 operational citrus packing stations in Morocco, achieving an 80% response rate (Bentaleb & Taki, 2023). The data analysis involved thematic analysis, Exploratory Factor Analysis (EFA), and simple regression, thus ensuring a comprehensive assessment of the effects of information system implementation. The results indicate that the successful integration of information systems has a substantial impact on reducing operating costs, improving inventory management, and enhancing delivery timeliness in the realm of CPS. These enhancements are of greatest significance for the sector's ability to effectively respond to the dynamic market demands and environmental constraints. Furthermore, the study emphasizes the significance of integrating information systems in order to achieve efficient supply chain management, particularly in managing perishable products like citrus fruits. Still, the study acknowledges its limitations since it primarily focuses on Moroccan CPS. This implies the necessity for cross-national research to provide more comprehensive perspectives (Bentaleb & Taki, 2023). The practical implications of this study are substantial for CPS and the broader agricultural sector, offering actionable insights for leveraging technology in optimizing supply chain operations. This research makes an important contribution by building upon the foundational research conducted by Bentaleb and Taki (2023) and providing empirical evidence on the operational impacts of information systems on SCM metrics within the agri-sector. It highlights the capacity of information systems to not solely address present challenges but also to proactively contribute to the development of a more effective and sustainable future for the farming industry as a whole.

Keywords: Information Systems Integration, Cost Efficiency, Inventory Management, Delivery Timeliness, Citrus Supply Chain Dynamics.
Classification JEL : Q13, O33, Q12, C88
Paper type: Empirical Research

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1. Introduction

Morocco's agricultural sector, pivotal to its national economy, has consistently displayed resilience amidst challenging climatic adversities. The growing 2022-2023 season was notably challenging, marked by a significant rainfall deficit of about 117mm below the 30-year average, translating to a 32% reduction (Ministry of Agriculture, 2023). This period of scarce rainfall, combined with irregular distribution and increased temperatures, extends a trend of adverse weather conditions prevalent over the past five years, including four years of drought. In this context, agricultural supply chains require cohesive integration as to include upstream and downstream collaborations for efficient movement of goods, data, and finances (Bentaleb & Taki, 2023; Oghazi, 2009; Oghazi et al., 2018; Wook Kim, 2006; Flynn et al., 2010; Wiengarten et al., 2016). Such integration is vital in addressing the sector's challenges, such as perishability and supply volatility, necessitating strategic management and coordination across the entire supply chain (Bentaleb & Taki, 2023; Patidar & Agrawal, 2020; Xiao, 2015; Gazdecki, 2018; Doukidis et al., 2007; Govindan, 2018). In spite of these daunting climatic and hydrological conditions, coupled with escalating production costs, Morocco's fruit tree and vegetable sectors have impressively sustained a good production level. This adaptability is reflected in the agricultural sector's growth, which saw a commendable 3% increase despite a 14.8% decline in the previous season (Ministry of Agriculture, 2023). Particularly impacted by these conditions is the citrus sector, an essential component of Moroccan agriculture. The 2022-2023 agri-season witnessed a notable downturn in citrus exports, decreasing by 38% to 476,000 tons from 766,000 tons in the 2021-2022 season (Ministry of Agriculture, 2023). This reduction in exports underscores the urgent need for enhanced supply chain management efficiency within the citrus sector, particularly in CPS, where the integration of information systems stands out as a key strategy to overcome these complexities. The pandemic's impact on these supply networks has further emphasized the need for transformative approaches, integrating advanced technologies to modernize and enhance resilience in agri-food supply chains (Bentaleb & Taki, 2023; Burgos & Ivanov, 2021; Melesse et al., 2023; Violi et al., 2023). The present study examines the implications of information system adoption on the operational efficiency of citrus packing stations in Morocco. The primary emphasis of this study is on the impact of IS integration on cost reduction, inventory management, and delivery timeliness. Such factors are of critical importance for CPS in order to effectively respond to fluctuating market demands and environmental challenges. The central research question probes into the effects of information system integration on enhancing supply chain resilience in challenging climatic and market conditions. Our aim is to provide practical and valuable insights into the role of technological advancements in strengthening a sector fundamental to Morocco's export economy, where supply chain precision and efficiency are crucial for maintaining market competitiveness. By exploring the relationship between information system integration and supply chain dynamics, this research seeks to provide concrete evidence on how technological interventions can potentially enhance operational performance metrics, including cost, inventory management, and delivery efficiency. The study thus addresses a significant gap in existing literature and serves as a guide for practitioners and policymakers aiming to utilize technology to enhance the efficiency of agri-supply chain operations (Bentaleb & Taki, 2023). This article methodically unfolds, starting with comprehensive assessment of the existing literature pertaining to the supply chain of CPS. Subsequently, the study proceeds to formulate research hypotheses and construct a research model based on literature analysis. Then, the research methodology is explicated, followed by the presentation and discussion of the results. The investigation concludes by combining the findings and proposing potential avenues for further research.

2. Supply Chain of Citrus Packing Stations

The integration of information systems has been identified as a catalyst for improving traceability, real-time monitoring, and data management efficiency, thereby enhancing decision-making quality within supply chains (Bentaleb & Taki, 2023). In the agricultural sector, particularly, this integration is critical for ensuring food quality, safety, and sustainability, addressing various uncertainties and risks impacting societal, economic, and environmental aspects (Bentaleb & Taki, 2023; Lezoche et al., 2020; Melesse et al., 2023). The recent pandemic has highlighted the vulnerability of global supply networks, underscoring challenges like unforeseen delays, cost management, collaboration barriers, and demand prediction inaccuracies (Bentaleb & Taki, 2023; Burgos & Ivanov, 2021; Melesse et al., 2023; Violi et al., 2023). This scenario necessitates a transformation in agri-food supply chains, advocating for centralized data, adaptability, and independent connections, where advanced technologies play a significant role in modernizing these chains (Bentaleb & Taki, 2023; Burgos & Ivanov, 2021; Melesse et al., 2023). While our previous research (Bentaleb & Taki, 2023) primarily addressed the variables of product quality and customer satisfaction in CPS, it also provided us with significant insights into the functioning of their supply chains. This aspect is particularly noteworthy, as while agricultural supply chains have been studied in various contexts, there is a notable gap in literature specifically concerning the supply chain logistics of citrus packing stations. The supply chain encompasses an intricate and complex set of processes that are essential for preserving the quality and marketability of citrus fruits. The complexity of these processes is crucial for comprehending the ways in which the integration of information technologies may improve operational efficiency and overall supply chain effectiveness. The arrival of citrus fruits from farms marks the commencement of a series of meticulously managed stages to ensure fruit quality and safety. Citrus fruit supply chain encompasses a thoroughly coordinated set of operations with the objective of ensuring optimal levels of fruit quality and safety. The phases include fungicide or pesticide treatments, a de-greening procedure aimed at enhancing consumer attractiveness, and a sequence of calibrations and quality assessments to guarantee the progression of only high-quality fruits. The application of wax coatings and subsequent drying operations serve to boost the aesthetic appeal and shelf life of the fruits. The technical services offered by the CPS are of paramount significance as they are responsible for supervising quality control procedures and provide vital technical support to farmers, covering aspects from sanitation and nutrition to pruning methods. Distribution within the Moroccan citrus packing sector, predominantly managed through maritime routes, has faced heightened challenges, exacerbated by the COVID-19 epidemic. These challenges include inflated logistics expenses and complexities related to the availability of marine lines, hence requiring rigorous management of transportation. Notably, the dominance of a single maritime company servicing Russia leads to distinct logistical and financial management complications for citrus stations. The different forms of transportation logistics, such as road transport to the European Union, vary depending on contractual terms with clients, impacting the logistics cost responsibilities. Moroccan regulations require that export transactions engaging local transport businesses must be conducted using domestic currency; introducing the need for extra currency conversion procedures and associated financial risks. It shows the significance of adopting cautious cash flow and financial management practices within this sector. This examination highlights the significant significance of every phase within the CPS supply chain, outlining the necessity of enforcing strict quality control protocols and guaranteeing efficient logistical management. The implementation of IS has the potential to significantly reinforce these operations, hence potentially enhancing resilience and competitiveness within the citrus sector.

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3. Hypothesis Development

In the realm of citrus packing stations, the quest for operational efficiency is paramount, with production costs being a critical determinant of profitability. The role of information systems in these settings is increasingly recognized for enhancing decision-making and automating key operations, a necessity given the perishable nature of citrus products. Studies have highlighted how the integration of IS can significantly improve operational efficiency, leading to cost reductions through more rapid processing and reduced waste (Prajová et al., 2021). This integration also streamlines communication and management, vital for maintaining product quality (Lupu, 2015; Nirwana, 2019). Consequently, the following hypothesis is suggested:

- ***H_1: Successful information system integration enhances operational cost reduction within citrus packing stations.***

Efficient inventory management is a critical aspect of CPS operations, particularly due to the perishability of citrus products. Zengwa (2016) confirms the role of IS integration in streamlining procurement and minimizing excess stock costs. Integrated systems facilitate precise management of citrus products, from reception to shipment, mitigating losses and enhancing operational cost-effectiveness (Mehta, 2016; Dessalegn, 2002; Alansari & Mishra, 2019). Thus, we propose the subsequent hypothesis :

- ***H_2: Successful information system integration enhances inventory management within citrus packing stations.***

The significance of ensuring timely delivery in the context of CPS is emphasized by the perishable nature of citrus commodities. with IS integration playing a critical role in this aspect. Prior research has noted the significance of IS in ensuring timely deliveries (Fleisch, 2001; Chen, 2011). Wognum (2011) further highlights the role of information technologies in enhancing transparency and sustainability in food supply chains. Integrated IS thus emerges as an essential tool for effective logistics management (Dhone, 2018; Baran & Galka, 2016; Rajapakse, 2023; Sudarsono et al., 2020). Based on these insights, the third research hypothesis is developed :

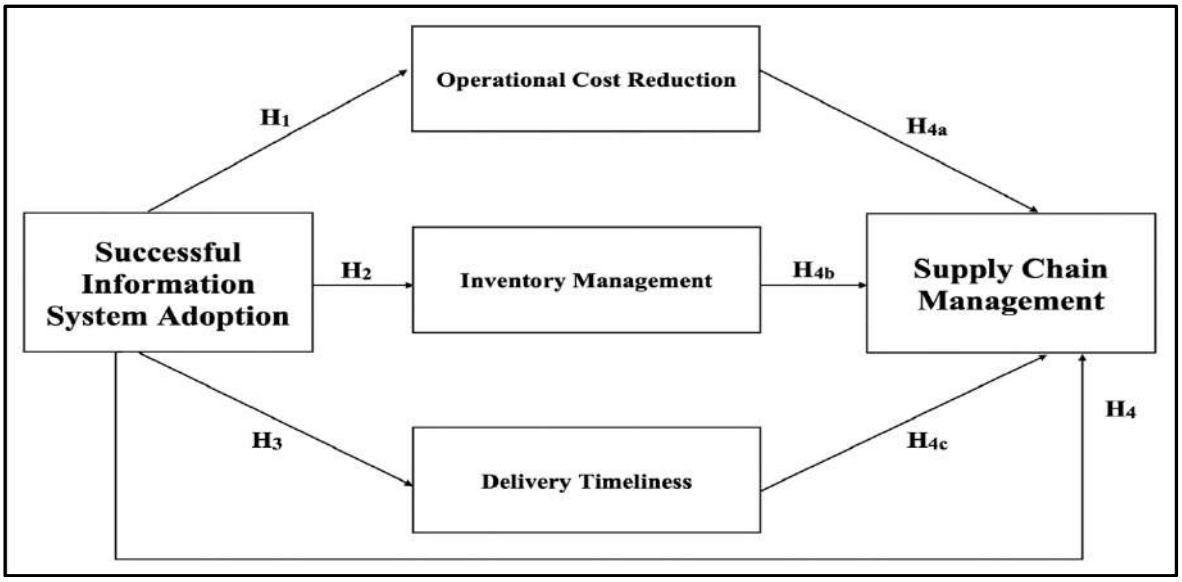
- ***H_3: Successful information system integration enhances delivery timeliness within Citrus Packing Stations.***

Research examinations have emphasized the need for innovative IT strategies in modern supply chains, particularly in contexts involving perishable goods like citrus fruits (Alzoubi & Yanamandra, 2020; Wang et al., 2016). The deployment of IT in CPS not only streamlines but also optimizes supply chain processes, leading to better planning, coordination, and flow management (Dehgani & Navimipour, 2019; Farshchi, 2015). Enhanced visibility and coordination, facilitated by IS, are key to minimizing delivery delays and improving efficiency, as well as reducing costs (Mena et al., 2002; Yanpirat & Choatheitmanut, 2014; Su, 2008; SangaleV et al., 2018; Jammernegg & Reiner, 2007; Singh & Kumar, 2011; Chalotra, 2013; Plinere & Arkady, 2015). Consequently, we formulate the following overarching hypothesis and its sub-hypotheses:

- ***H_4 : Successful information system integration enhances supply chain management within Citrus Packing Stations.***
  - **H_{4a} :** Enhanced operational cost reduction positively impacts supply chain management within Citrus Packing Stations.
  - **H_{4b} :** Enhanced inventory management positively impacts supply chain management within Citrus Packing Stations.
  - **H_{4c} :** Enhanced delivery timeliness positively impacts supply chain management within Citrus Packing Stations.

The conceptual framework guiding the empirical investigation within citrus packing stations is represented by the research model, which displays the interrelated connections and dynamics of the developed hypotheses. This model is illustrated in
Figure 1:

Figure 1: Conceptual Framework



Source : Authors

4. Research Methodology

The methodology employed in this study is based on the mixed methods approach formerly used in our past research (Bentaleb & Taki, 2023). The integration of qualitative depth and quantitative breadth in this technique is in accordance with the evolving norms in social science research and provides extensive understanding of intricate phenomena (Leavy, 2022; Vivek & Nanthagopan, 2021; Sakata, 2022).

4.1.Research Design

This study employs a sequential exploratory design, which begins with qualitative analysis and progresses to quantitative exploration. In the qualitative phase of this research, semi-structured interviews were conducted with Chief Executives, Information System Directors, and Supply Chain Managers from five Citrus Packing Stations. ***Table 1:*** succinctly presents the characteristics of these CPS, including their geographic locations, sizes, annual packing capacities, and the roles of the interviewees involved:

Table 1: Characteristics of Interviewees in the Qualitative Study

Interviewee Code	Location	Role/Quality	Duration of Interview	CPS Characteristics
A1	Marrakesh	Chief Executive	**1h30**	Area: 4.5 ha Packing Capacity: 25,000 tons/year
B1	Marrakesh	Chief Executive		Area: 1 ha Packing Capacity: 17,000 tons/year
B2	Marrakesh	IS Director		
C1	Agadir	Supply Chain Manager		Area: 5 ha Packing Capacity: 80,000 tons/year
D1	Casablanca	Chief Executive		Area: 3 ha Packing Capacity: 40,000 tons/year
E1	Casablanca	Chief Executive		Area: 1 ha Packing Capacity: 15,000 tons/year
E2	Casablanca	Supply Chain Manager		

Source: Authors

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These interviews were instrumental in understanding the complexities of CPS logistics and the role of information systems in operational efficiency, specifically targeting areas such as cost efficiency, inventory control, and delivery timeliness. This qualitative exploration was foundational in generating survey items for the subsequent quantitative phase, which involved disseminating a questionnaire to all 50 operational CPS in Morocco, achieving a substantial 80% response rate (Bentaleb & Taki, 2023). This methodology ensured a comprehensive understanding of the impact of information system integration on the new variables of interest.

4.2. Analysis

The analysis phase began with thematic analysis of the qualitative data, transitioning to Exploratory Factor Analysis (EFA) and simple regression for the quantitative data, processed using SPSS (version 29). The EFA incorporated Bartlett's test and the Kaiser-Meyer-Olkin (KMO) measure for assessing construct validity (Delacroix et al., 2021; Evrard et al., 2009). This process involved filtering out items with communalities below 0.4 to maintain strong factor representation. Reliability assessment utilized Cronbach's alpha to ensure internal consistency of the measurement scales (Cronbach, 1951). Regression analysis was conducted to explore the individual impacts of each independent variable on supply chain management in CPS, considering the overall quality of regression and statistical significance through the coefficient of determination (R^2) and the F-test (Giannelloni & Vernette, 2001). This comprehensive analytical approach ensured the clarity and applicability of the findings to the field of supply chain management in citrus packing stations.

5. Empirical Results

5.1.Exploratory Qualitative Phase

In this study, we extend the exploration of the critical elements of Successful Information System Adoption, previously identified in our prior research (Bentaleb & Taki, 2023). These elements, encapsulating aspects such as internal and external communication, product traceability, and the analysis of key performance metrics (Bentaleb & Taki, 2023), are re-examined here to ascertain their influence on new operational variables. This reevaluation focuses on the impact of IS integration on key operational areas: operational cost reduction, inventory management, and delivery timeliness within citrus packing stations.

Operational Cost Reduction

The integration of software capable of instantaneously calculating operational costs at each stage of the processing chain has played a transformative role in reducing operational costs in CPS. While not initially designed as a management control tool, systems like OMNIPACK have become essential for comprehensive cost assessment, tracking every palette's treatment, storage time, and journey within the station. This detailed monitoring feeds into new software for exhaustive cost evaluations. A standout feature of these systems is their proactive alert function, which signals any deviations from standard storage times, enabling swift action to reduce product quality deterioration and waste. Beyond product tracking, these systems are instrumental in resource management, monitoring stock levels, evaluating progress against weekly objectives, and facilitating necessary schedule adjustments. Additionally, modules focusing on farm performance provide insights into productivity, allowing for targeted resource allocation where needed most. On the logistics front, these systems offer a specific module to monitor and manage expenditures, tracking the performance of various logistic service providers in detail. This comprehensive approach, coupled with the integration of additional systems like LOGISTA and ERP DYNAMICS AX, has significantly minimized errors in

packaging and quality activities, reduced delays, and enhanced the judicious use of capital and time, collectively contributing to a marked reduction in operational costs within CPS. Table 2 provides a comprehensive analysis of the essential components that underscore the significance of information systems in facilitating operational cost reduction at citrus packing stations:

Table 2: Items "IS-Operational Cost Reduction"

Description	Item Code	Item	Scale Type
Role of Information System in Operational Cost Reduction	**ISOCR1**	Integration and Cost Calculation	**Likert scale 1 = Strongly Disagree to 5 = Strongly Agree**
	ISOCR2	Palette Traceability	
	ISOCR3	Cost Evaluation by Stage	
	ISOCR4	Alerts on Storage Duration	
	ISOCR5	Optimal Resource Management	
	ISOCR6	Monitoring of Weekly Objectives	
	ISOCR7	Farm Performance Evaluation	
	ISOCR8	Logistics Expenditure Monitoring	
	ISOCR9	Monitoring Service Provider Actions	
	ISOCR10	Control of Logistic Expenses	

Source: Authors

Inventory Management

Information Systems, adept at handling a wide array of packaging types, accessories, and pallet configurations, render manual inventory management obsolete, bringing about unprecedented operational efficiency and optimized stock control. The real-time, comprehensive inventory insights offered by the IS enable CPS to make informed decisions regarding order fulfillment capabilities and necessary adjustments in supply levels. This is particularly vital in managing customer orders and maintaining stock visibility, crucial elements in ensuring prompt and reliable delivery. A notable feature of the information systems is its commercial program module, which seamlessly integrates order management. Orders are instantly recorded in the system, ensuring accurate processing based on available stock levels and preventing any oversight or neglect of customer requests. Additionally, the information system's interconnectedness with the stock system plays a pivotal role in signaling inventory deficiencies for particular demands, thereby proactively alerting the management about potential challenges in fulfilling orders due to stock limitations. This proactive approach not only ensures efficient order management but also maintains optimal delivery timelines. Furthermore, the reduction of losses and wastage is significantly reinforced by the IS. By providing a clear picture of existing inventory, the system helps in avoiding redundant purchases, thus minimizing wastage and unnecessary expenses. Citrus packing stations can also configure the IS to send timely alerts about impending stock shortages. When stocks approach critical levels, quick alerts to warehouse managers enable immediate action, ensuring a consistent stock replenishment process. Table 3 presents the elements influencing inventory management in CPS, emphasizing the role of IS:

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Table 3: Items "IS-Inventory Management"

Description	Item Code	Item	Scale Type
Role of Information System in Inventory Management	**ISIM1**	Real-time Inventory Visibility	**Likert scale 1 = Strongly Disagree to 5 = Strongly Agree**
	ISIM2	Integrated Order Management	
	ISIM3	Immediate Order Entry	
	ISIM4	Instantaneous Stock Deficit Signaling	
	ISIM5	Stock Deficit Alerts	
	ISIM6	Avoidance of Redundant Purchases	
	ISIM7	Stock Outage Anticipation	
	ISIM8	Critical Stock Threshold Alerts	
	ISIM9	Reduction of Losses and Wastage	

Source: Authors

Delivery Timeliness

Integrated information systems have introduced a level of transparency and real-time access that has revolutionized how commercial programs are managed and expedited. Further, the adoption of systems like FRESHTRACK across interviewed stations underscores the critical role of IS in coordinating logistical and commercial activities. By integrating their commercial schedules into the IS, stations can plan operations in sync with shipping availabilities, ensuring readiness for predetermined shipping dates to key destinations. This proactive planning approach is vital, given the rigid schedules typical in maritime logistics. Specific modules within the IS, dedicated to export operations, further streamline this process. These modules allow stations to input detailed loading information post-production, granting the shipping department immediate access to all relevant data regarding ready-to-ship pallets, including client-specific instructions. The wide range of readily available information enables the effortless scheduling of container shipments with various service providers. Such an automated and centralized process significantly eases coordination among all stakeholders in the supply chain, effectively managing contingencies and reducing delivery timelines. The culmination of these IS capabilities translates to enhanced agility in the face of operational complexities, ensuring timely delivery and reinforcing the competitive edge of CPS in the dynamic citrus market.Table ***4*** delineates the specific items utilized to assess the impact of information system integration on the enhancement of delivery timeliness within citrus packing stations:

Table 4: Items "IS-Delivery Timeliness"

Description	Item Code	Item	Scale Type
Role of Information System in Delivery Timeliness	**ISDT1**	Commercial Program Visibility	**Likert scale 1 = Strongly Disagree to 5 = Strongly Agree**
	ISDT2	Expedition Forecast Facilitation	
	ISDT3	Immediate Visibility on Prepared Pallets	
	ISDT4	Synchronization of Deliveries with Maritime Schedules	
	ISDT5	Expedition Data Centralization	
	ISDT6	Rapid Stock Data Access	
	ISDT7	Documentation of Shipping Requirements	
	ISDT8	Expedition Process Automation	

Source: Authors

Confirmatory Quantitative Phase

Exploratory Factor Analysis and Reliability Measurement

The adequacy and inter-correlations of the variables – Operational Cost Reduction, Inventory Management, and Delivery Timeliness – were evaluated using the Kaiser-Meyer-Olkin measure and Bartlett's Test of Sphericity, as illustrated in
Table ***5*:**

Table 5: KMO index and Bartlett's test results

KMO and Bartlett's Test		***Operational Cost Reduction***	***Inventory Management***	***Delivery Timeliness***
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.912	.899	.905
Bartlett's Test of Sphericity	Approx. Chi-Square	445.231	546.399	467.749
	df	45	36	28
	Sig.	<.001	<.001	<.001

Source: Authors

The KMO measure, a determinant for the adequacy of sample size, yielded high values for all three variables: 0.912 for Operational Cost Reduction, 0.899 for Inventory Management, and 0.905 for Delivery Timeliness. These values, significantly exceeding the commonly accepted threshold of 0.5, suggest that the sample size is sufficiently adequate for a reliable factor analysis. Furthermore, Bartlett's Test of Sphericity confirms the suitability of the data for structure detection. The significance level for all tests was less than 0.001, indicating that the variables are inter-correlated and suitable for factor analysis.
Table 6 outlines the Principal Component Analysis for the variables Operational Cost Reduction, Inventory Management, and Delivery Timeliness in Citrus Packing Stations, presenting only components with eigenvalues above 1 as per Kaiser's criterion.

Table 6: Principal Component Analysis Results

Total Variance Explained : Operational Cost Reduction			
Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	7.397	73.975	73.975
Total Variance Explained : Inventory Management			
Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	7.603	84.476	84.476
Total Variance Explained : Delivery Timeliness			
Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	6.994	87.419	87.419
Extraction Method : Principal Component Analysis.			

Source: Authors

The PCA results for Citrus Packing Stations indicate a significant concentration of variance within a single component for each variable: Operational Cost Reduction (7.397 eigenvalue, 73.975% variance), Inventory Management (7.603 eigenvalue, 84.476% variance), and Delivery Timeliness (6.994 eigenvalue, 87.419% variance), each demonstrating a singular, dominant dimension in their respective areas.
The PCA component matrix for the variables Operational Cost Reduction, Inventory Management, and Delivery Timeliness in Citrus Packing Stations provides detailed component loadings for each item within these variables, as illustrated in

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***Table 7*:**

Table 7: PCA Component Matrix Results

Component Matrix[a]					
Operational Cost Reduction	**Component** 1	**Inventory Management**	**Component** 1	**Delivery Timeliness**	**Component** 1
ISOCR1	.794	ISIM1	.862	ISDT1	.927
ISOCR2	.857	ISIM2	.924	ISDT2	.933
ISOCR3	.928	ISIM3	.940	ISDT3	.940
ISOCR4	.880	ISIM4	.957	ISDT4	.917
ISOCR5	.906	ISIM5	.907	ISDT5	.968
ISOCR6	.883	ISIM6	.878	ISDT6	.897
ISOCR7	.800	ISIM7	.949	ISDT7	.952
ISOCR8	.723	ISIM8	.925	ISDT8	.944
ISOCR9	.874	ISIM9	.924		
ISOCR10	.932				
Extraction Method : Principal Component Analysis.					
a. 1 components extracted.					

Source: Authors

The component loadings for Operational Cost Reduction (.723 to .932), Inventory Management (.878 to .957), and Delivery Timeliness (.897 to .968) in Citrus Packing Stations all exhibit strong correlations with their respective principal components, suggesting a significant alignment of items with key components in each variable. These high loadings across all three variables underscore a robust relationship with their respective principal components, indicating a cohesive structure within each variable.

The results of Cronbach's Alpha, presented in Table 8**,** demonstrate high reliability for each variable.

Table 8: Reliability Analysis Results

Reliability Statistics					
Operational Cost Reduction		**Inventory Management**		**Delivery Timeliness**	
Cronbach's Alpha	N of Items	Cronbach's Alpha	N of Items	Cronbach's Alpha	N of Items
.960	10	**.977**	9	**.979**	8

Source: Authors

Operational Cost Reduction, Inventory Management, and Delivery Timeliness present high internal consistency, with Cronbach's Alpha values of .960 (10 items), .977 (9 items), and .979 (8 items) respectively, confirming the reliability of the scales for each variable.

Hypothesis Validation via Simple Linear Regression

Linear regression analysis was conducted to assess the relationships between the research variables, following preliminary tests for normal distribution. The assumptions intended for validation are outlined in Table 9**:**

Table 9: Hypothesis for Linear Regression Analysis

Hypothesis	Independent Variable	Dependent Variable
H_1	Successful IS Integration	Operational Cost Reduction

H_2	Successful IS Integration	Inventory Management
H_3	Successful IS Integration	Delivery Timeliness
H_4	Successful IS Integration	Supply Chain Management
H_{4a}	Enhanced Operational Cost Reduction	Supply Chain Management
H_{4b}	Enhanced Inventory Management	Supply Chain Management
H_{4c}	Enhanced Delivery Timeliness	Supply Chain Management

Source: Authors

The regression analysis results, as presented in Table 10, provide insightful findings regarding the impact of successful information system integration on various aspects of supply chain management within citrus packing stations. The study employs adjusted R2 for evaluating model efficacy, providing a conservative and more accurate fit assessment by accounting for the number of predictors in the model (Bentaleb & Taki, 2023).

Table 10: Regression results applied to research hypothesis variables

	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4	H_{4a}	H_{4b}	H_{4c}
R	.852	.782	.812	.832	.968	.981	.984
R Square	.725	.612	.659	.692	.937	.963	.969
Adjusted R^2	.718	.601	.684	.684	.935	.962	.968

Source : Authors

The adjusted R2 values for Hypotheses 1, 2, and 3, addressing the impacts of information system integration on operational cost reduction, inventory management, and delivery timeliness respectively, explain 71.8%, 60.1%, and 68.4% of the observed variability in these areas within Citrus Packing Stations. The overarching Hypothesis 4, focusing on the impact of information system integration on overall supply chain management, demonstrates an adjusted R2 of .684. The sub-hypotheses - H4a on operational cost reduction, H4b on inventory management, and H4c on delivery timeliness - exhibit particularly robust adjusted R2 values of .935, .962, and .968, respectively, indicating a substantial explanation of the observed variability in these specific supply chain aspects within Citrus Packing Stations.

The ANOVA results for the hypotheses as shown in Table 11 provide clear evidence supporting the research hypotheses:

Table 11: ANOVA applied to Hypotheses variables

ANOVA : Hypothesis 1						
	Model	Sum of Squares	df	Mean Square	**F**	**Sig.**
1	Regression	25.928	1	25.928	**100.314**	**<.001**
ANOVA : Hypothesis 2						
	Model	Sum of Squares	df	Mean Square	**F**	**Sig.**
1	Regression	28.171	1	28.171	**59.838**	**<.001**
ANOVA : Hypothesis 3						
	Model	Sum of Squares	df	Mean Square	**F**	**Sig.**
1	Regression	32.623	1	32.623	**73.560**	**<.001**
ANOVA : Hypothesis 4						
	Model	Sum of Squares	df	Mean Square	**F**	**Sig.**
1	Regression	28.841	1	28.841	**85.299**	**<.001**
ANOVA : H_{4a}						
	Model	Sum of Squares	df	Mean Square	**F**	**Sig.**
1	Regression	39.050	1	39.050	**562.084**	**<.001**
ANOVA : H_{4b}						
	Model	Sum of Squares	df	Mean Square	**F**	**Sig.**
1	Regression	40.158	1	40.158	**996.519**	**<.001**
ANOVA : H_{4c}						

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Model		Sum of Squares	df	Mean Square	**F**	**Sig.**
1	Regression	40.381	1	40.381	**1172.461**	**<.001**

Source: Authors

For Hypothesis 1, concerning the impact of information system integration on operational cost reduction, the F-value of 100.314 with a significance level less than .001 indicates a strong model fit. Hypothesis 2, focusing on inventory management, also shows the statistical significance of the model with an F-value of 59.838. Similarly, Hypothesis 3 on delivery timeliness displays an F-value of 73.560, again indicating a significant relationship. In the case of Hypothesis 4, assessing the overall impact of information system integration on supply chain management, the ANOVA results show an F-value of 85.299, suggesting a substantial model fit. The sub-hypotheses further demonstrate this trend: H4a (F-value = 562.084), H4b (F-value = 996.519), and H4c (F-value = 1172.461), all with significance levels below .001, indicate strong model effectiveness. These results collectively provide robust statistical validation for the proposed relationships between information system integration and key aspects of supply chain management in CPS. Statistical evaluations demonstrate a pronounced positive association between the integration of information systems and critical operational dimensions within Citrus Packing Stations. The regression coefficients for Hypotheses H1 (Operational Cost Reduction), H2 (Inventory Management), and H3 (Delivery Timeliness) underscore the beneficial influence of successful information system integration on these specific aspects. Additionally, Hypothesis H4, along with its sub-hypotheses H4a, H4b, and H4c, confirms that such integration markedly bolsters the overarching efficacy of supply chain management within citrus packing stations.

6. Discussion

Considering the empirical data, the importance of information systems in improving operational efficiency at Moroccan Citrus Packing Stations (CPS) is distinctly highlighted. The results corroborate prior studies (Prajová et al., 2021; Andion, 2017), showing the critical role of information system integration in operational cost reduction, inventory management, and enhanced delivery timeliness. The observed improvements in operational cost efficiency and inventory management corroborate with insights from Zengwa (2016) and Alansari & Mishra (2019), highlighting the value of real-time inventory insights and integrated order management. Moreover, the enhancement in delivery timeliness resonates with the assertions of Fleisch (2001) and Chen (2011) regarding the criticality of timely logistics in agriculture. Our results extend the discourse beyond operational enhancements, positioning information system integration as a strategic asset within the broader context of supply chain management. This is particularly relevant given the climatic challenges faced by the Moroccan citrus sector, underscoring the need for agility and adaptability in supply chain operations. The research suggests that integrated information systems are not just tools for operational efficiency but also catalysts for strategic transformation, enabling CPS to navigate fluctuating market demands and environmental challenges effectively.

7. Conclusion

This study's in-depth investigation of information system integration within Moroccan Citrus Packing Stations, with a particular focus on cost efficiency, inventory control, and timeliness, builds upon and extends the foundational work of Bentaleb & Taki (2023). This exploration into the strategic impact of information systems in the Moroccan citrus sector, a key element of the national economy, has been conducted amidst the challenging climatic conditions of the 2022-2023 agricultural season (Ministry of Agriculture, 2023). The findings support and

expand upon earlier research (Prajová et al., 2021), reinforcing the crucial role of information systems in enhancing operational efficiency in citrus packing stations. These systems have proven important in achieving operational cost reduction, effective inventory management, and enhanced delivery timeliness, thus catering to the sector's requirements for adapting to fluctuating market demands and environmental challenges (Lezoche et al., 2020; Melesse et al., 2023; Burgos & Ivanov, 2021; Violi et al., 2023). Furthermore, the integration of information systems is recognized as key to efficient supply chain management, especially for perishable products like citrus fruits, thereby echoing the need for innovative IT strategies in supply chain optimization (Alzoubi & Yanamandra, 2020; Wang et al., 2016). Employing a sequential exploratory design, this study melds qualitative depth with quantitative breadth, yielding comprehensive perspectives into the complexities of the phenomenon (Leavy, 2022; Vivek & Nanthagopan, 2021; Sakata, 2022). This research not only underscores the crucial role of information systems within the Moroccan citrus packing industry but also establishes a foundation for future exploration within the broader agri-food sector. It accentuates the necessity for an integrated approach in managing supply chains effectively, capable of adapting to various challenges, including climatic adversities and market fluctuations. While offering valuable insights, this study recognizes its limitations, notably its primary focus on Moroccan citrus packing stations. It calls for future broader, cross-national research that could validate and expand these findings, providing deeper understanding into the role of information systems across different agricultural, climatic, and economic contexts (Bentaleb & Taki, 2023). In conclusion, this research makes a significant contribution to the discourse on the strategic role of information systems in agriculture. It emphasizes their potential in not only navigating current challenges but also in proactively shaping a more efficient and sustainable future for the agricultural sector.

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