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# DO INFORMATION AND COMMUNICATION TECHNOLOGIES AFFECT THE PERFORMANCE OF A SUPPLY CHAIN? PIECES OF EVIDENCE FROM THE TUNISIAN FOOD SECTOR

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**Abstract:** This paper examines the impact of the use of information and communications technologies on the overall performance of the supply chain in the Tunisian food sector. The information and communication technologies (ICTs) considered for this research are: Enterprise Resource Planning (ERP), Electronic Data Interchange (EDI), Customer Relationship Management (CRM), Transport Management System (TMS), Warehouse Management System (WMS) and Radio-frequency Identification (RFID). From a large sample survey (n= 82) of manufacturing firms operating in Tunisian food sector, results collected by using multiple regression with SPSS statistical software show that only ERP and CRM have a significant impact on the performance of supply chain in the context of Tunisian food sector.

**Keywords:** Information and Communication Technologies, Supply Chain, Performance, Food industry.

**MSC:** 90B30.

## 1. INTRODUCTION

Supply chain management (SCM) deals with the effective management of supply chain activities to ensure and maximize customer value and achieve a competitive advantage ([30],[34]). Organizations need to modernize their supply

chains and increase their efficiency through a continuous integration of information and communication technologies ([14]; [1]; [52]). For instance, the use of ICT ensures real-time information flow across the chain, reduces uncertainty, and enhances the performance of the whole supply chain system. ITC is also used to increase transparency and manage relevant risks [54].

Despite the literature consensus regarding the vital and significant role of ICTs in enhancing the organizational performance, the supply chain analytics in the developing countries is still in its initial stage. Moreover, there are little empirical evidences about the contribution of ICTs in the performance of the supply chain systems for small and medium enterprises (SMEs). Thus, a need arises to enhance the understanding of the impact of the use of Information and Communication Technology (ICT) on the performance of supply chain, particularly for small and medium enterprises (SMEs) in the developing countries.

## 2. THEORETICAL FRAMEWORK

In a supply chain, the businesses operate in the form of interconnected or interlinked networks, channels and node businesses for the provision of products and services required by end customers. Supply chain management (SCM) may be conceived as the management of the flow of goods and services that includes the movement and storage of raw materials, work-in-process inventory, and finished goods from point of origin to point of consumption. A conventional definition of SCM is the "design, planning, execution, control, and monitoring of supply chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply with demand and increasing the performance globally. In the new paradigm, businesses may no longer survive as autonomous units but as supply chains [9], with multiple linkages between production and service entities" [30]. Through strategic collaboration, firms within the chain can have a direct and profound impact on cost, quality, delivery, and responsiveness of all partners.

Information is the decision making key for any kind of business. Prior to the 1980s, a significant portion of the information used to flow between functional areas within an organization, and between supply-chain members, were paper-based. In many instances, these paper-based transactions and communications were slow, unreliable, and error prone. Conducting business in this manner was costly and was decreasing the firms' effectiveness in being able to design, develop, procure, manufacture, and distribute their products. During this period, information was often overlooked as a critical competitive resource because its value to supply chain members was not clearly understood. However, firms that are embarking upon supply chain management initiatives recognize the vital role of information and the technologies that make this information available. In a sense, the information systems and the technologies utilized in the supply chain represent one of the fundamental elements that link the organizations into a unified and coordinated system. In the current competitive climate, little doubt remains about the importance of information and information technology to the ultimate

success, and perhaps even the survival of any supply chain management initiative: cycle time reduction, implementing redesigned cross - functional processes, utilizing cross-selling opportunities and capturing the channel to the customer.

Actually, timely and accurate information is more critical now than at any time. Three factors have strongly impacted this change in the importance of information management. According to Reix [42], the information technology (IT) facilitates vertical communication and eliminates mediating managers known by their role of information transmitters. In order to meet the market requirements, companies are used to look always for solutions in order to reduce costs and improve quality and performance [6]. These improvement efforts require good coordination between the different parts of the chain partners, particularly in terms of information exchanges.

Research has shown information technology to be an effective means of promoting collaboration between firms organized into networks [49]. Effective coordination of supply chain activities, by means of excellent information technology processes, has recently been identified as essential to organizational performance [21]. One of the primary goals of these systems is to replace inventory with perfect information. For example, Xerox provides master production schedules (MPS) online to suppliers to facilitate just-in-time delivery, leading to reduced inventory costs and improved buyer-supplier relationships [37].

Actually, information technologies constitute a key success of any today's organization. The impact of Information Technologies (IT) on the performance of the supply chain management remains a fertile area of investigation, especially in the context of developing countries. Few empirical studies have dedicated to assess the link between using information technologies and the overall performance of the supply chain management of the involved organizations. Performance measurement is generally defined as the process of quantifying the efficiency and effectiveness of action [27]. Effectiveness is the extent to which customer's requirements are met, while efficiency measures how economically a firm's resources are utilized to achieve a predetermined level of customer satisfaction.

## 3. CONCEPTUAL MODEL

In this paper we address the impact of the following information technologies on the performance of the supply chain management: ERP (Enterprise Resource Planning), EDI (Electronic Data Interchange),CRM (Customer Relationship management), TMS (Transportation Management Systems), WMS (Warehouse Management System), and finally the RFID (Radio-Frequency Identification). In the next sub-sections, we analyze each of those dimensions, showing its impact on the SCM performance.

### *3.1. ERP*

Jean-Louis Lequeux [28] defines ERP as an application having at least the following modules: business management, CAPM (Assisted Production Management Computer), accounting and financial management, human resources,

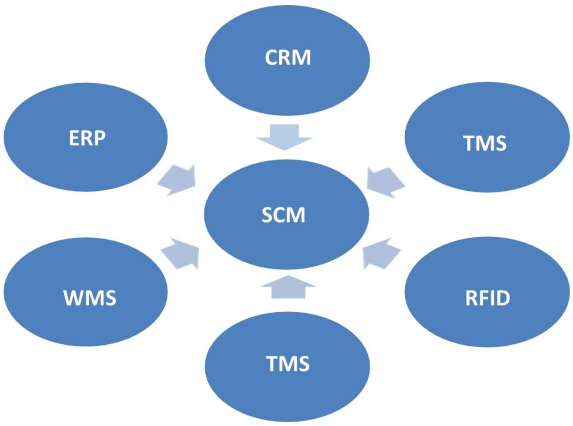


Figure 1: Conceptual Model

customer management, planning management. For Jean-Louis Tomas [47], the information processing in the company is changing. Fundamental changes (euro, increased competitiveness, acquisitions, mergers, globalization, etc.) are leading more and more companies to migrate their internal IT applications to ERP (Enterprise Resource Planning), which offer transversal, homogeneous, integrated, efficient and scalable solutions.

ERP systems can be considered as an information technology infrastructure that is able to facilitate the flow of information between all supply chain processes in an organization [19]. The ERP systems represent an optimum technology infrastructure that, when integrated properly with a process-oriented business design, can effectively support supply chain management systems [8].

Organizations are investing in ERP systems to improve their financial as well as non-financial performance ([36]; [26];[17];[45]). Shang and Seddon [46] propose an ERP benefit framework for summarizing benefits in the use of ERP systems. Their framework provides a convenient means of identifying the business benefits that an organization has realized in the post-implementation phase of the ERP system life cycle by presenting five dimensions of business benefits: operational, managerial, strategic, IT infrastructure, and organizational and multiple business benefit categories within each dimension.

Velcu [50] adopts an ”inside the black-box” approach to analyze economic benefits of ERP systems by examining what business process (BP) changes take place in companies that have different motives for implementing ERP systems. He discovered that Companies having a technologically-led motivation perceive ”improved service time in accounting tasks” as an internal efficiency benefit, ”faster response to business change” as customer benefits, and financial benefits in terms of other improved efficiencies. Companies that have a business-led motivation perceive ”economies of scale” as an internal efficiency benefit, and financial benefits in terms of ”lower headcount costs” and ”lower selling, general

and administrative costs". Both groups of companies report BP changes in terms of "reassignment of financial management of business cases".

Shaio-Yan, Ching-Wen, Seng-Lee, and Ming-Chun [16] have also investigated the impact of Enterprise Resource Planning (ERP) implementation on business performance. The empirical results show that ERP implementation can positively affect the process capital of Intellectual Capital (IC); process capital can positively affect customer capital, and customer capital, ultimately, affects business performance. Companies implementing ERP can build process capital to meet the challenges of the competitive market environment.

In general, the implementation of ERP was confirmed to have a positive effect on the organizational performance. It increases the profits of the company, reduces the operating cost, increases customers and partners satisfaction, and enhances the firms competitive advantage.

***H1: The integration of ERP affects positively the overall performance of the supply chain management in small and medium enterprises.***

### *3.2. EDI*

Electronic Data Interchange (EDI) is another example of information technology used to increase the performance of the firms' supply chain management. Electronic Data Interchange (EDI) is not just an electronic ordering system, it helps to integrate stocking, logistics, materials acquisition, shipping and other functions to create a more proactive and effective style of business management and customer responsiveness [24], and thereby improve competitive advantage [7].

Supply chain is a network of businesses that offers inter-firm integration through the flow of information, material, and finance ([39]; [35]; [54]. EDI is a procedure by which an organization can exchange structured business documents (purchase orders and invoices, for example) with its trading partners. Using a structured and readable machine format allowing the transfer of documents from one application to another, located in a different place, without interpretation or other human intervention. The EDI was designed to replace the transmission of information on paper and to overcome the inefficiency of manual systems. Hence, the use of this information technology facilitates the organization in managing knowledge exchange with its supply chain partners more effectively. Electronic Data Interchange system exists inside the organizations in various forms including e-supply chain, data analytics, information processing, cloud computing, etc. The organizations practice of electronic knowledge exchange facilitates the integration within the supply chain, which further enhances the organizational performance [2]. Similarly, electronic data exchange can also facilitate internal and external information management of the organization which has been found positively associated with internal and external process management and subsequent operational performance in Australian firms [38]. Electronic data exchange also facilitates the organizational use of different data analytics for knowledge exchange with the stakeholders. The most recent form of electronic data exchange between supply chain partners is through cloud computing. In a recent study [33]

on Malaysian manufacturing, companies have revealed the positive contribution of cloud computing technology for informational management on innovation and firm performance.

***H2: The Integration of EDE affects positively the performance of the supply chain of SMEs.***

### *3.3. CRM*

The third pillar of information technology is customer relationship management (CRM). The organizations collect and store affluent data regarding their customers, suppliers, and other business partners. The inability of the organization to transform this data into valuable and useful knowledge [5] may bring it towards a competitive disadvantage. CRM is defined as the strategic use of information, processes, technology, and people to manage the customers relationship with your company (Marketing, Sales, Services, and Support) across the whole customer life cycle. The foundation of CRM systems lies in customer data and information technology (IT) [25] to support the business strategy for building long term and profitable relationships with the customers [29]. The Big-Data enabled CRM to be one of the key success factors for the organizations [53]. CRM has also a significant effect on the firms' intensity of collaboration with customers and on its performance [41]. The CRM has a positive effect on sales increase, customer satisfaction, profitability, and customer loyalty ([18]; [31]).

***H3: The integration of CRM affects positively the overall performance of the supply chain of SMEs.***

Managing transportation and logistics has been a critical focus area for manufacturers, distributors, and third-party logistics players in their pursuit of developing a lean, agile, and efficient customer oriented supply chain.

In their groundbreaking paper of 2008, Green, Whitten and Imman [13] found that logistics performance and supply chain management strategy positively impact marketing performance. The effective logistics management has also been reported to have positive effects on firm financial and non-financial performance [44].

### *3.4. TMS*

The TMS or transport management system is a tool to ensure managing a fleet of trucks and drivers, organizing loading schedules, delivering, unloading, and billing. Many organizations are using intelligent transportation management systems to facilitate the collection, processing, and management of real-time traffic data [32].

The information technology (IT) capabilities enable manufacturers to optimize their operations [12]. Thus, effective transportation management systems enable the firm to optimize its operations and achieve better performance than the competitors. Effective transportation management systems, which are based on effective information technology integration (e.g. personal rapid transit), facilitate the transportation service due to short waiting time and without intermediate stops.

It is also considered as a tool to enhance the overall supply chain performance of a company and provide a competitive advantage.

***H4: The automated TMS affects positively the overall performance of the supply chain of SMEs.***

### *3.5. WMS*

The management of Inventory and warehouse is crucial to maximize value of the supply chain of every organization. Warehouse management system is a computer information system of preparation, monitoring and execution of transactional warehouse activities. In today's competitive market, the use of ICT has become a strong tool driving the success of many organizations supply chains [20].This has revolutionized the role of warehousing for the companies in customize their value proposition and increasing the levels of their customer satisfaction [40]. The Warehouse Management Software allows optimization of a warehouse operation: a perfect stock assessment, optimization of transportation costs, the disappearance of errors in preparation, adaptation means that work required [23].

The warehouse management systems increase companies' competitive advantage and the performance of their supply chain through the reduction of transportation cost and economies of scale [4] and shortening response time [12]. Wang and Gu [51] implemented a data warehouse-based management system which improved the performance of supply chain system by enabling the organization to provide prompt responses to diversified customer demands. Atieh et al. [3] found significant effect of the implementation of an automated warehouse management system on supply chain performance which facilitated inventory management system for an enhanced, efficient, and timely handling.

***H5: The integration of WMS tool affects positively the supply chain of SMEs.***

### *3.6. RFID*

Today, the companies use information technology to design the warehouse management systems through various means including radio frequency identification (RFID) technology. This technology is used for tracking purposes of merchandise, shipping containers, vehicles, and even pets. An electronic reader can then use radio signals to read or track objects.

RFID technology offers the prospect of improved efficiency by more sophisticated inventory management, delivering lower costs and improved results. It also offers opportunities to reduce theft and counterfeiting. More accurate demand analysis furthermore improves marketing planning. However, a main disadvantage is the high set-up and implementation cost. Other technical concerns are reliability and electronic interference. Perceived obstacles thus militate against adoption [43].

RFID technology has opened a new huge market in the domain of supply chain [10]. Actually, the application of RFID and internet in the new logistics management modes has totally changed the dynamics of coordination between the supply chain partners. RFID presents a great opportunity for leaders to take

their supply chain performance to a superior level [48]. The implementation of RFID practices significantly affects the supply chain performance by improving the performance of distribution systems. Overall, the recent empirical and theoretical research evidence supports the view that the integration of RFID facilitated the organizations in improving the performance of its supply chain.

***H6: The integration of RFID has a positive and direct impact on the overall performance of the supply chain of SMEs.***

## 4. RESEARCH METHODOLOGY AND RESULTS

To collect relevant information, a self-administered questionnaire is used to evaluate the perception of Tunisian SMEs managers of the role of ICTs on the performance of the supply chain. This study targets a sampling firms operating in the foods industry. A total of 82 questionnaires are administered by mail. Out of the 82 questionnaires distributed, only 51 are found useful. An exploratory analysis is conducted first to ensure the reliability of measures. A multiple regression analysis is conducted to evaluate the impact of ICTs on the performance of the supply chain.

Exploratory factor analysis (EFA) was utilized to operationally redefine various dimensions of ITCs and the performance included in the research model. EFA is the technique that defines the possible relationships in the most general form, and then allows for multivariate techniques to estimate the relationships ([15], [11]). The EFA has two main objectives: data summarization and data reduction [15]. The following subsections show the factor analysis for the two mains concepts: ITC and Performance.

A reliability analysis for every dimensions of the ITC has been conducted in order to study the internal consistence between items for each variable. Coefficients are presented in table 1.

Table 1: Reliability Analysis

| variable | proper value | index KMO | Bartlett's test | Cronbach's Alpha | average variance explained |
|---|---|---|---|---|---|
| ERP | 301.452 | 0.883 | 0.00 | 0.948 | 79.66% |
| EDI | 207.775 | 0.869 | 0.00 | 0.955 | 88.17% |
| CRM | 171.433 | 0.859 | 0.00 | 0.938 | 84.51% |
| TMS | 176.898 | 0.862 | 0.00 | 0.940 | 84.78% |
| WMS | 109.551 | 0.809 | 0.00 | 0.886 | 75.03% |
| RFID | 193.441 | 0.847 | 0.00 | 0.0947 | 86.53% |
| Performance | 180.225 | 0.879 | 0.00 | 0.795 | 87.03% |

According to this first step of analysis, results show that the dimensions of performance, "ERP", "EDI" , "CRM", "TMS", and "WMS" arrange a coefficient $\alpha > 0.7$ (they are in the order of 0.948; 0.955; 0.938; 0.940 and 0.886) without making any modification to their content. However, for the dimension "RFID", a coefficient of reliability alpha is too weak to reach the level of acceptability. Therefore, this dimension leaves our basis of calculation since it has no effect.

In the next step, a multiple regression has been done where the dependent variable (DV) is regressed under a set of variables. It serves to analyze the relationship between a qualitative DV and a set of independent variables (IV). Each IV is evaluated by the regression procedure in a way to maximize the prediction of the DV.

The regression searches the combination of weights ($b$) for the independent variables ($X_i$) that leads the values of predicted $Y$ by the equation as close as possible to the values of measured $Y$:

$$Y_i = a + b_1X_1 + b_2X_2 + ... + b_nX_n \quad (1)$$

The multiple regression method is complicated by the presence of multicolinearity. In fact, majority of studies usually use correlated independent variables. To detect the level of correlation between variables, it is recommended to calculate tolerance and inflation factor of the variance (IFV). Tolerance is defined as the part of variability of the IV not explained by at least one of the other IVs. A high tolerance corresponds to a low degree of colinearity. The level of 0.3 is recommended. Conversely, the level of IFV should be below 3.The results of the multiple-regression are shown in the following tables (2 and 3).

The table 2 includes the introduced variables: the ERP and CRM. We can see that EDI, TMS, and WMS are not taken into consideration due to their insignificant contribution to the regression.

Table 2: Introduced/eliminated variables[a]

| Model | Introduced variables | Eliminated variables | Method |
|---|---|---|---|
| 1 | **ERP** | | Step by step (criteria: probability of F to introduce ≤ 0.05, probability of F to eliminate ≥ 0.1) |
| 2 | **CRM** | | (criteria: probability of F to introduce ≤ 0.05, probability of F to eliminate ≥ 0.1) |

a.Dependent variable: performance of the supply chain logistics.

The two variables (ERP and CRM) explain 52% of the supply chain performance (Adjusted $R^2$).

Table 3: Summary of the Model[c]

| Model | $R$ | $R^2$ | Adjusted $R^2$ | Standard error of estimation |
|---|---|---|---|---|
| 1 | 0.727[a] | 0,499 | 0,498 | 0,752 |
| 2 | 0.872[b] | 0,52 | 0,518 | 0,743 |

a. Predicted values (constants), ERP
b. Predicted values (constants), ERT, CRM
c. Dependent variable: supply chain performance.

The table of ANOVA shows that both models are significant (Significance = 0.00).

Table 4: ANOVA[c]

| Model | Square Sum | DF | Square mean | F | significance |
|---|---|---|---|---|---|
| 1 Regression | 352.40 | 1 | 352.40 | 639.053 | 0.000[a] |
| Residual | 350.50 | 641 | 0.566 | | |
| Total | 702.90 | 642 | | | |
| 2 Regression | 371.85 | 2 | 185.927 | 338.001 | 0.000[b] |
| Residual | 352.05 | 640 | 0.550 | | |
| Total | 723.90 | 642 | | | |

a. Predicted values (constants), ERP
b. Predicted values (constants), ERT, CRM
c. Dependent variable: supply chain performance.

Table 5 shows results of the colinearity test. We can see that tolerance and inflation factors of the variance IFV are close to the unit, falling under the recommended limits (tolerance > 0.3 and IFV < 3.3). Hence, the independent variables are then little correlated, which is an indicator of the quality of the model.

We can finally conclude that the model 2 is satisfactory, as it explains 52% of the supply chain performance (adjusted $R^2$).

Table 5: Diagnoses of Colinearity[a]

| Model | PV | Index of conditioning | Proportion of the variance | | |
|---|---|---|---|---|---|
| | | | Constant | ERP | CRM |
| 1 1 | 1.951 | 1.000 | 0.02 | 0.02 | |
| 2 | 0.049 | 6.330 | 0.98 | 0.98 | |
| 2 1 | 2.910 | 1.000 | 0.01 | 0.01 | 0.01 |
| 2 | 0.060 | 6.937 | 0.07 | 0.95 | 0.23 |
| 3 | 0.030 | 9.911 | 0.92 | 0.04 | 0.76 |

a. Dependent variable: supply chain performance.

We can finally say that ERP and CRM are the main determinants of the supply chain performance.

## 5. DISCUSSION

Results of the multiple regression show that the ERP and the CRM are the main determinants of the supply chain performance, which confirms previously found results of the other research. However, there are no statistically positive relationship between ”EDI”, ”TMS”, ”WMS” ”RFID”, and the supply chain performance. Results inform that the current situation of the Tunisian food sector is not taking benefit from the new technologies available and used by competitors

in developed countries. This delay can be explained by many reasons. Firstly, the food sector is composed mainly of Small and medium companies and is not classified as a strategic one in Tunisian economy as there is a lack of investment during the last decennia. Also, the sector's financial health is in poor condition, with overall farmer debt estimated at TD1bn (€458.6m). In addition to the financial issues, others are related to the suppliers working in this sector. They are facing a lot of agriculture environmental degradation (land and water). Secondly, investing in high information technologies is considered as a strategic decision which requires funds competencies and time. It is still considered by managers of Tunisian SMEs as a huge investment with low Return on Investment. Tunisian managers do not have courage to invest in this area because of their financial fragility and the smallest size of the Tunisian market. Thirdly, the instability of Tunisian context obliges big organizations and MNCs to relocate their operations. Fourthly, the profile of Tunisian managers is still classic. Several studies show that the performance of the firms in the Mediterranean area is still hugely dependent on the entrepreneurship style. They seem to apply a "wait and see" attitude upgrading policies. Their approach is not proactive and is more reactive, which does not fit the principle of flexibility and reactivity.

## 6. CONCLUSION

Where conclusion emerging from this study validates some of the key linkages and supports beliefs and evidence by researchers regarding the relationships between supply chain and performance, results are alarming. Businesses are reluctant to implement such practices due to their unknown performance outcomes. Serious actions should be taken by the Government, Businesses, and all stakeholders to upgrade this sector through encouraging policies, fostering linkage between businesses and research centers, and setting priorities for this sector. On the other hand, managers should be aware of the benefits of Information and Communication Technologies for the performance of their operations by allowing their manufacturing systems to be more flexible. They are also encouraged to hire qualified people who bring added value to their supply chain.

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