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A structural equation model for analyzing the relationship between enterprise resource planning and digital supply chain management

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A B S T R A C T

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Digitization and the internet are new phenomena which have greatly changed the way in which modern-day businesses are run. Enterprise resource planning (ERP) is one such system developed as a result of digitization in order to improve firm supply chain efficiency. This study investigated the relationship between digital and sustainable supply chain (in this case the ERP system) and firm competences of supply chain management. 33 respondents from e-commerce firms volunteered to take part in the data collection process of the study, with a majority of them being information technology (IT) managers. The hypothesized relationships were analyzed using structural equation modelling (SEM). Findings of the study depict that all the hypothesized relationships were significant ($p<.001$) at the 1 % level of significance, implying that there exists a positive effect of the ERP systems on firm performance.

1. Introduction

Supply chain management is one aspect which plays an integral role in current-day businesses. However, there has been increasing competition in supply chain processes among firms. This has called for innovative and modern solutions to ensure that firms maintain a competitive advantage against their competitors. This firm competition has led to the digital supply chain which ensures that firms remain relevant in the dynamic and changing business environment. Digital supply chain management can be described as a set of processes which utilize advanced technology and offer better insights along with business stakeholders to make informed decisions concerning where to obtain, demand, or sell their products (Wang et al., 2018). There is a growing concern in all directions of business and management of developing sustainable systems which are likely to grow and offer a competitive advantage for businesses in an ever-changing business environment. In the e-commerce industry, for instance, the concept of a digitized supply chain management system has been suggested as one of the ways of improving firms' performance (Gravili, 2018). However, considering the fact that digital products, like e-commerce and websites, specialized B2B software products, or something else, one can find out the long list of key providers based on product type and the industry which the product fits in. Looking closely at this wide list as a supply chain might assist IT companies in Jordan to develop their own security systems, and support customers with trusted indicators from many service providers, which enable them to make rational decisions in such products. Likewise, IT security staff can understand how the company fits within several digital supply chains to improve their security systems. Once IT companies can be able to map different levels of connections, then they can better understand many surface attacks. This present paper seeks to provide a report on the relationship between digital and sustainable supply chain (in this case the ERP system) and firm competences of supply chain management by conducting a structural equation modelling.

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2. Literature Review

A fully integrated supply chain management system ensures that factors of demand and supply are at their optimal states to ensure efficiency, reliability, and efficacy in procurement processes. The last couple of years have witnessed increased globalization and technological advancement which have led to an evolved competitive advantage among firms, with businesses making efforts to improve their ability to favorably compete in the increasingly changing and competitive business field, thus the rise of the digital supply chain management systems. Advanced technologies which include cloud computing, big data, and block-chain are responsible for the rise of digital supply chain management systems (Govindan et al., 2018).

The digitization of the supply chain has an impact on the sustainability of supply chain processes. Sustainable supply chain management can be described as the firms' strategic efforts to attain social, environmental, and economic goals through the linkage of buyer-supplier, and inter-organizational business processes (Nasiri et al., 2020). Digitization of the supply chain processes improves monitoring of the demand, supply, and logistics processes which integrate sustainability performance criteria into the process of optimal and efficient selection of product suppliers (Perboli et al., 2018). The overall achievement of the integration of technology and sustainable supply chain processes is an improved supplier-selection process and efficient time management and cost effectiveness. The digital supply chain is still a field under development and can further be polished to improve efficiency in the supply chain processes. It entails both relational and structural integration of supply chain processes (Ivanov et al., 2018). The integration of these two aspects ensure that visibility is enhanced, and demand volatility uncertainties or risks are reduced. For instance, the digital supply chain management systems provide for the real-time visualization and tracking of information sharing among global supply chain partners (Liu, 2019). Among the factors which enable this global and real-time monitoring of procurement processes are the internet of things, big data analytics, and artificial intelligence.

Literature on the business models being employed in the internet age is growing at a rapid pace (Tsang et al., 2018). demonstrates that with changing business paradigms brought about by globalization, supply chain designs should be changing too, as it has become a core competence. The present day digital and sustainable supply chain systems are characterized by the adoption of the enterprise resource planning (ERP) systems. The adoption of such systems has been orchestrated by pressure from competitors, stakeholder requests, and system upgrades to replace the less efficient traditional or legacy systems (Tseng et al., 2019). ERP systems have been found to have significantly positive effects on businesses which include reduction in the supply chain process time, better management of firm finances, and improved transparency and accountability over the supply chain process. One such industry which has highly adopted the Enterprise Resource Planning (ERP) System, which is an aspect of the digital and sustainable supply chain, is the E-Commerce Industry. This paper seeks to investigate how some of the components of the digital and sustainable supply chain affect the e-commerce industry in Jordan, based on the analysis of data obtained from a sample of e-commerce firms. The findings of the study will help in highlighting the importance and the need to adopt digitization in the supply chain process. However, the study seeks to follow the below conceptual model and research hypotheses.

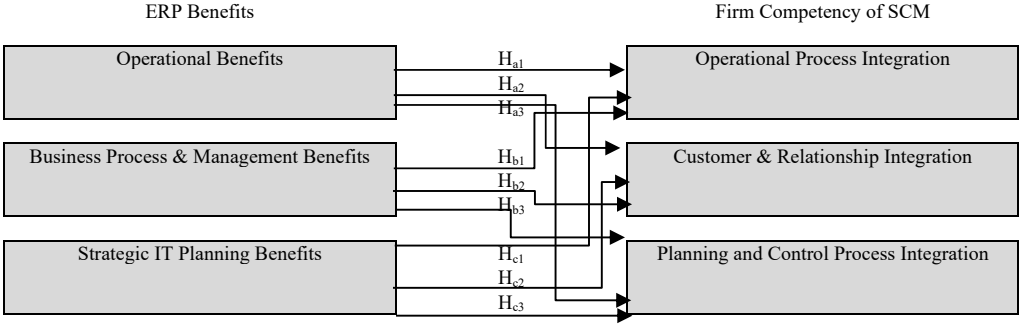

Fig. 1. Conceptual model and hypotheses

H_{a1}: *There is a positive effect of the operational benefits of ERP systems on operational process integration.*
H_{a2}: *There is a positive effect of the operational benefits of ERP systems on customer and relationship integration.*
H_{a3}: *There is a positive effect of the operational benefits of ERP systems on planning and control process integration.*
H_{b1}: *There is a positive effect of the business process and management benefits of ERP systems on operational process integration.*
H_{b2}: *There is a positive effect of the business process and management benefits of ERP systems on customer and relationship integration.*
H_{b3}: *There is a positive effect of the business process and management benefits of ERP systems on planning and control process integration.*
H_{c1}: *There is a positive effect of the strategic IT planning benefits of ERP systems on operational process integration.*
H_{c2}: *There is a positive effect of the strategic IT planning benefits of ERP systems on customer and relationship integration.*

H_{c3}: *There is a positive effect of the strategic IT planning benefits of ERP systems on planning and control process integration.*

3. Materials and Methods

3.1 Instrument design

The study followed a two-stage normative process of developing scales for measuring the study variables. The first stage involved identifying the constructs of ERP benefits and factors hypothesized to have benefits on the supply chain process. The process of scale development involved reviewing relevant literature on ERP and supply chain management (SCM) in order to decide on which scales to adopt. The literature touched the aspects of ERP and SCM on operational management, strategic management, organizational management, and information technology (IT). Based on the conceptual definition of the identified constructs, the study items were developed. The constructs identified questionnaires as a potential method of collecting the study data. A preliminary pilot study was conducted in order to test the effectiveness and validity of the study instruments and reviewed by the IT managers of the chosen e-commerce firm in Jordan. 8 IT managers were identified from the branches of the firm under study. Results of the pre-test found that questionnaires were an appropriate method of collecting data from the study participants. The items were modified following responses from the 8 IT experts who participated in the pilot exercise. A five-point Likert scale with 1 representing "strongly disagree". 2 representing "disagree", 3 representing "neither agree nor disagree", 4 representing "agree", and 5 representing (strongly agree" was used in obtaining responses to questions which involved rating agreement about given statements, while some questions were answered on numerical scale.

The final study questionnaire consisted of 30 items for 6 constructs, and the number of questions were 10. The questions sought to obtain information on the e-commerce industry, number of employees in the chosen firm, company revenue, type of digital supply chain management systems used by the firm, and the length of time the firm has been using the system.

3.2 Data collection

Data was collected from a sample of e-commerce firms listed in the Jordan Stock exchange market. Items tapping into each of the study constructs were used in obtaining responses to the study questions. Firms to participate in the study were screened by accessing the Jordan Stock Exchange database and the websites of e-commerce companies listed with the stock exchange. A total of 10 e-commerce firms were sampled into the study. Introductory letters were sent to the managing directors of the companies, detailing to them the aims of the study and the ethical considerations and implications of the study. The letters were accompanied by the study questionnaire which managing directors forwarded to selected IT or supply chain managers. In order to assure the participants of data ethical protocols, the e-mail assured that the participant responses would be kept confidential, their identity kept anonymous, and the privacy of all the information shared. After several follow-up emails, a total of 18 IT managers and 15 supply chain managers volunteered to participate in the study.

3.3 Data analysis

The collected data was analyzed for both descriptive and inferential statistics, with structural equation modelling (SEM) being used for investigating the variable relationships hypothesized by the study. Exploratory factor analysis was first conducted in order to confirm whether or not the proposed factor structures are consistent with the actual data. The analysis was carried out using the SPSS and AMOS software.

4. Results

4.1 Exploratory factor analysis

As depicted in Table 1 below, results of the study suggest that factor structures in the EFA math those proposed in the model.

Table 1
Exploratory factor analysis (EFA)

Construct		Components						
	Items	**1**	**2**	**3**	**4**	**5**	**6**	**Communality**
Operational benefits of ERP	OP1	0.75	0.18	0.13	0.21	0.18	0.16	0.68
	OP2	0.74	0.15	0.15	0.18	0.23	0.16	081
	OP3	0.82	0.12	0.91	0.18	0.19	0.22	0.79
	OP4	0.72	0.09	0.09	0.09	0.21	0.19	0.77
	OP5	0.85	0.22	0.21	0.22	0.20	0.14	0.87
	OP6	0.76	0.25	0.24	0.19	0.23	0.15	0.80

Table 1
Exploratory factor analysis (EFA) (Continued)

Construct		Components						
	Items	**1**	**2**	**3**	**4**	**5**	**6**	**Communality**
Strategic IT planning benefits of ERP	SIP1	0.12	0.79	0.18	0.22	0.17	0.18	0.77
	SIP2	0.11	0.72	0.25	0.17	0.18	0.17	0.82
	SIP3	0.09	0.62	0.22	0.16	0.21	0.22	0.79
	SIP4	0.16	0.73	0.17	0.17	0.19	0.15	0.76
	SIP5	0.17	0.82	0.19	0.19	0.21	0.23	0.74
	SIP6	0.19	0.77	0.16	0.20	0.20	0.19	0.71
Business process and management benefits of ERP	BPM1	0.18	0.21	0.77	0.19	0.21	0.16	0.62
	BPM2	0.19	0.23	0.79	0.16	0.19	0.19	0.69
	BPM3	0.18	0.22	0.72	0.17	0.17	0.17	0.78
	BPM4	0.20	0.19	0.75	0.18	0.21	0.11	0.80
	BPM5	0.17	0.19	0.78	0.20	0.20	0.14	0.77
	BPM6	0.21	0.20	0.76	0.19	0.18	0.15	0.79
Operational process integration of SCM	OP1	0.20	0.11	0.16	0.77	0.17	0.19	0.78
	OP2	0.16	0.16	0.08	0.79	0.19	0.16	0.81
	OP3	0.21	0.09	0.14	0.69	0.21	0.20	0.77
	OP4	0.19	0.21	0.13	0.81	0.16	0.22	0.74
	OP5	0.21	0.17	0.17	0.82	0.13	0.17	0.75
	OP6	0.17	0.14	0.18	0.78	0.20	0.13	0.69
Customer and relationship integration of SCM	CR1	0.12	0.08	0.19	0.16	0.69	0.12	0.72
	CR2	0.16	0.12	0.21	0.17	0.82	0.09	0.68
	CR3	0.14	0.16	0.16	0.20	0.63	0.17	0.79
	CR4	0.19	0.14	0.15	0.21	0.72	0.18	0.74
	CR5	0.18	0.16	0.19	0.19	0.73	0.15	0.72
	CR6	0.15	0.20	0.18	0.15	0.77	0.19	0.81
Planning and control process integration of SCM	PC1	0.18	0.22	0.19	0.23	0.19	0.79	0.63
	PC2	0.21	0.24	0.15	0.16	0.16	0.63	0.69
	PC3	0.16	0.19	0.17	0.19	0.13	0.77	0.75
	PC4	0.18	0.18	0.13	0.14	0.18	0.74	0.72
	PC5	0.17	0.16	0.18	0.16	0.21	0.75	0.77
	PC6	0.20	0.21	0.21	0.09	0.15	0.72	0.69
Eigen values		15.62	2.62	2.41	1.92	1.65	1.23	
% of variance		44.17	7.28	6.81	4.99	4.41	3.52	
Cumulative %		44.17	51.45	58.26	63.25	67.66	71.18	

Table 2
Summary of constructs

Construct Name	Identifier	Initial no. of Items	No. of items carried for analysis
Operational benefits of ERP	OP	6	6
Business Process and Managerial benefits of ERP	BPM	6	6
Strategic IT planning benefits of ERP	SIP	6	6
Operational process integration of SCM	OP	6	6
Customer and relationship integration of SCM	CR	6	6
Planning and control process integration of SCM	PC	6	6

4.2 Instrument reliability and validity

The Cronbach's alpha for all the items are all above 0.70 implying that there is high internal consistency among the items. As depicted in Table 2 above, all the items were retained.

Table 3
Summary of the measurement model

Construct	Components							
	Indicator	**Mean**	**S.D**	**Item-to-total correlation**	**Std loading**	**Cronbach's alpha**	**Compose reliability**	**Average variance extracted estimates**
Operational benefits of ERP	OP1	4.47	0.61	0.76	0.75	0.93	0.92	0.76
	OP2	4.70	0.59	0.84	0.89			
	OP3	4.75	0.62	0.88	0.92			
	OP4	4.78	0.64	0.92	0.95			
	OP5	4.52	0.66	0.89	0.93			
	OP6	4.76	0.65	0.90	0.94			

Table 3
Summary of the measurement model (Continued)

Construct	Components							
	Indicator	**Mean**	**S.D**	**Item-to-total correlation**	**Std loading**	**Cronbach's alpha**	**Compose reliability**	**Average variance extracted estimates**
Strategic IT planning benefits of ERP	SIP1	4.62	0.69	0.78	0.72	0.92	0.91	0.67
	SIP2	4.71	0.62	0.75	0.87			
	SIP3	4.56	0.63	0.82	0.86			
	SIP4	4.62	0.64	0.77	0.77			
	SIP5	4.51	0.62	0.79	0.79			
	SIP6	4.53	0.67	0.86	0.90			
Business process and management benefits of ERP	BPM1	4.27	0.61	0.87	0.79	0.90	0.92	0.62
	BPM2	4.32	0.63	0.79	0.86			
	BPM3	4.55	0.72	0.72	0.77			
	BPM4	4.45	0.59	0.85	0.84			
	BPM5	4.62	0.69	0.78	0.82			
	BPM6	4.61	0.60	0.76	0.79			
Operational process integration of SCM	OP1	4.27	0.52	0.72	0.82	0.94	0.95	0.67
	OP2	4.16	0.62	0.69	0.80			
	OP3	4.14	0.56	0.82	0.86			
	OP4	4.29	0.55	0.78	0.79			
	OP5	4.18	0.61	0.73	0.88			
	OP6	4.25	0.50	0.77	0.85			
Customer and relationship integration of SCM	CR1	4.28	0.52	0.79	0.76	0.91	0.91	0.62
	CR2	4.34	0.56	0.81	0.78			
	CR3	4.56	0.53	0.76	0.80			
	CR4	4.48	0.55	0.85	0.73			
	CR5	4.39	0.62	0.77	0.81			
	CR6	4.42	0.57	0.72	0.80			
Planning and control process integration of SCM	PC1	3.81	0.59	0.66	0.89	0.93	0.82	0.64
	PC2	3.77	0.55	0.68	0.79			
	PC3	3.90	0.59	0.74	0.69			
	PC4	3.66	0.62	0.63	0.81			
	PC5	3.71	0.56	0.57	0.82			
	PC6	3.75	0.57	0.78	0.78			

The composite reliability values all range above 0.80, implying high internal consistency among the 6 constructs. The average variances extracted from the measures range above 0.60 which implies that they are above the acceptability region of 0.5.

4.3 Factor loadings

Table 4 below depicts the loadings of the measures involved in the study. On checking the significance of the factors based on the t-values, it is found that all measures are significant at the 1 % level of significance.

Table 4
Factors Loadings

Construct	Items	Std. loading	Std. error	t-value
Operational benefits of ERP	OP1	0.74	0.07	15.47
	OP2	0.89	0.05	19.87
	OP3	0.92	0.04	20.01
	OP4	0.95	0.05	23.12
	OP5	0.93	0.06	19.21
	OP6	0.94		
Strategic IT planning benefits of ERP	SIP1	0.72	0.08	13.41
	SIP2	0.87	0.09	11.06
	SIP3	0.86	0.08	14.42
	SIP4	0.77	0.07	12.96
	SIP5	0.79	0.07	12.44
	SIP6	0.90		
Business process and management benefits of ERP	BPM1	0.79	0.07	16.02
	BPM2	0.86	0.06	18.46
	BPM3	0.77	0.06	13.22
	BPM4	0.84	0.07	15.48
	BPM5	0.82	0.05	14.56
	BPM6	0.79		

Table 4
Factors Loadings (Continued)

Construct	Items	Std. loading	Std. error	t-value
Operational process integration of SCM	OP1	0.82		
	OP2	0.80	0.08	15.50
	OP3	0.86	0.07	14.47
	OP4	0.79	0.06	15.81
	OP5	0.88	0.07	17.04
	OP6	0.85	0.07	17.22
Customer and relationship integration of SCM	CR1	0.76		
	CR2	0.78	0.07	13.44
	CR3	0.80	0.08	13.18
	CR4	0.73	0.08	14.39
	CR5	0.81	0.07	14.40
	CR6	0.80	0.08	14.50
Planning and control process integration of SCM	PC1	0.89		
	PC2	0.79	0.09	10.43
	PC3	0.69	0.09	11.09
	PC4	0.81	0.09	9.97
	PC5	0.82	0.09	11.32
	PC6	0.78	0.08	10.68

4.4 Comparison of average variance extracted and squared correlations

The results in Table 5 below confirm the discriminant validity, with the average extracted variance for each of the constructs being greater than the correlations of the constructs. The inter-construct correlations depict that there is a larger variance between each construct and its measures than with other measures.

Table 5
AVE against squared correlations

Variable	OP	BPM	SIP	OP	CR	PC
OP	**0.76**					
BPM	0.37	**0.63**				
SIP	0.28	0.36	**0.62**			
OP	0.32	0.41	0.29	**0.50**		
CR	0.44	0.48	0.56	0.33	**0.66**	
PC	0.25	0.31	0.28	0.42	0.33	**0.61**

Note: AVE are on the diagonal while squared correlations are on the off-diagonal.

4.5 The structural equation model

The study used some indicators which most researchers depend on to decide the model goodness of fit, chi square test (**χ2**), the comparative fit index **CFI**, the goodness of fit index **GFI**, the normed fit index NFI, the Tucker-Lewis index **TLI** and the root mean square error of approximate **RMESA**. Each of them has a clear value below. However, the structural model shown in figure 1 was tested in this study using **AMOS**. The results are as shown in below table:

Table 6
Tested model

χ2	1149	GFI	0.802
df	548	RMR	0.021
χ2/df	2.097	RMSEA	0.062
Normed fit index (NFI)	0.867	Lower bound	0.057
Tucker-Lewis index	0.919	Upper bound	0.067
Comparative fit index (CFI)	0.925		

The statistic of 2.097 is within the acceptance region, and therefore the model can be used to accurately model the relationships between the study variables.

4.6 Model fit

Based on the model fit results and after checking all indicators, the results in Fig. 3 below depict that all the hypotheses are supported.

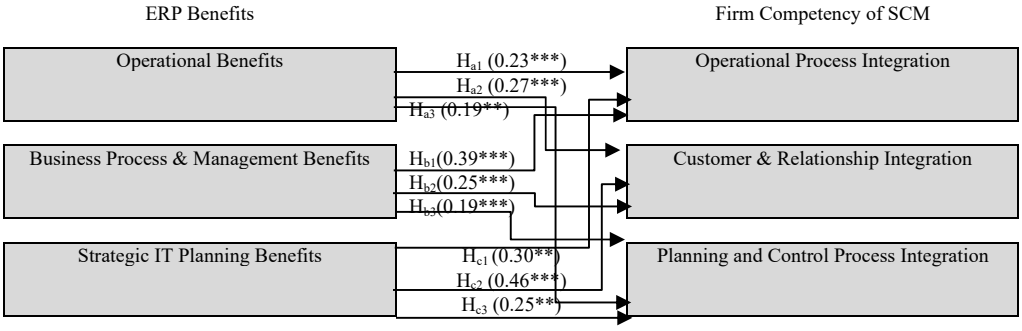

Fig. 3. Model fit results

5. Discussion

The study investigated the relationship between digital and sustainable supply chain (in this case the ERP system) and firm competences of supply chain management.

5.1 Operational benefits of the ERP system

The hypotheses Ha1, Ha2, and Ha3 are supported (0.23, 0.39, 0.30, p<.001) at the 1 % level of significance. This implies that there is a positive effect of the operational benefits of ERP systems on planning and control process integration, operational process integration, and the customer and relationship integration process.

5.2 Business process and management benefits of the ERP system

The hypotheses Hb1, Hb2, and Hb3 are supported (0.27, 0.25, 0.46, p<.001) at the 1 % level of significance. This implies that there is a positive effect of business process and management benefits of the ERP system on planning and control process integration, operational process integration, and the customer and relationship integration process.

5.3 Strategic IT planning benefits of the ERP system

The hypotheses Hc1, Hc2, and Hc3 are supported (0.19, 0.19, 0.25, p<.001) at the 1 % level of significance. This implies that there is a positive effect of strategic IT planning benefits of the ERP system on planning and control process integration, operational process integration, and the customer and relationship integration process.

These findings are consistent with those of (Govindan et al., 2018; Holmström & Partanen, 2014) who demonstrated that there exists a positive relationship between digitization of the supply chain management process and firm performance.

6. Managerial implications and recommendations

According to Bataineh (2021) supply chain management is a critical area to study in the Arab world, since it impacts a lot of sectors. Business leaders across the world are required to adopt sustainable managerial and operational systems which might give them the opportunity to get advantage over their competitors and allow them to freely interact with other stakeholders in order to learn new methods of sustainable management that could help them improve their business processes in order to distinguish themselves from their competitors. The study found that there exists a significant impact of the ERP system on business planning and control, operation, and customer relationships. The study therefore recommends that firms in the e-commerce industry adopt the ERP supply chain system to improve individual firm performance.

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