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Advancing e-commerce adoption among SMEs in Jordan: A path to digital transformation

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Abstract

This research identifies how technological aspects help small and medium-sized businesses in Jordan develop their e-commerce activities. Critical technological elements investigated in this research consist of the ICT infrastructure, digital payment systems, cybersecurity, and technological literacy. Small and medium-sized enterprises must adopt e-commerce to thrive within the fast-evolving digital global marketplace. All significant factors assessed during this research showed that technological literacy stood out as the primary driver for e-commerce success by allowing SMEs to utilize digital tools efficiently. Digital payment systems establish reliable payment mechanisms for online purchases, which build consumer trust, while cybersecurity protects personal customer information and strengthens consumer trust. Jordanian SMEs struggle with digital transformation because they have limited ICT infrastructure alongside scarce transformative resources. The researchers gathered structured survey responses from 121 SMEs located throughout Jordan. All selected SMEs for this research had completed at least five years of business operation according to random selection criteria. SPSS served as the platform through which researchers surveyed relationships between technological aspects and e-commerce integration. Research outcomes deliver appropriate guidance for policymakers and business figures, enabling them to expand SME potential and accelerate e-commerce penetration in Jordan.

Keywords: SMEs, E-Commerce adoption, Technological factors

1. Introduction

Modern business operations base their operations on technological advancement, which establishes itself as a central force for digital age competitive advantage and innovation [1]. E-commerce platforms provide SMEs with a major business potential, although these organizations represent the core element in numerous countries' economic systems [2]. The private sector development in Jordan depends heavily on SMEs since they offer a critical answer to employment troubles [3]. The inconsistent growth of e-commerce for Jordanian SMEs persists despite worldwide digitalization because technical and infrastructural restrictions continue to be problematic. Through online selling platforms, small and medium enterprises (SMEs) achieve broader customer connections and operational improvement while also strengthening their interaction with customers [4]. E-commerce technology success requires the implementation of four essential components: ICT infrastructure, cybersecurity technologies and technological training, and digital payment security [5,2,6]. Small and medium enterprises operating in Jordan encounter poor internet access as well as limited utilization of secure payment systems and

inadequate digital capabilities [7]. The situation requires collaborative work at scale to boost technological capabilities and develop digital infrastructure that provides support [8,9,10]. The analysis evaluates how technological elements affect e-commerce deployment in Jordanian small and medium enterprises. The TOE framework shows that business performance, together with e-commerce system integration, depends on both ICT infrastructure availability and payment system security against cybersecurity threats and technological ability. The research investigates how Jordanian SMEs embrace e-commerce using present-day ICT infrastructure while analyzing digital payment systems that affect business expansion, along with cybersecurity issues and technological competencies required for digital environment success. This study brings together relevant factors to deliver practical guidance to management executives as well as government officials who want to advance digital transformation among SME businesses. It further enhances academic comprehension of e-commerce adoption in developing economies through concrete recommendations for developing Jordanian SMEs' digital preparedness, which protects their digital stability and preserves their market sustainability in global electronic settings.

2. Literature review and hypothesis development

2.1. Theoretical background

Small and medium-sized enterprises have become significant drivers of economic expansion throughout various developing countries, including Jordan [11]. Through e-commerce technology, SMEs can both enhance their innovative practices and improve customer relations while optimizing business operations [12]. The successful completion of targets depends heavily on technological elements that incorporate ICT systems together with digital payment systems and cybersecurity methods, as well as the user's ability to operate technology [13]. It provides organizations with an established analysis structure for understanding the relationships between technological and organizational factors and environmental elements affecting e-commerce adoption by small and medium-sized enterprises [14]. Adopting innovative practices like e-commerce depends on three connected dimensions according to the TOE framework, characterized as technological readiness and organizational capability, and external environmental factors [15]. The research investigates technological elements that help Jordanian SMEs achieve successful e-commerce system utilization. The evaluation relies on academic sources to evaluate the implementation factors of e-commerce models through digital technology infrastructure combined with transactional platform security measures and artificial intelligence technology capabilities [16,17].

3. ICT infrastructure

The majority of experts accept that modern infrastructure supports e-commerce operations effectively [4]. Professionals and scholarly studies both confirm that e-commerce requires an ICT infrastructure for its proper execution [18]. The adoption of e-commerce depends directly on the set ICT infrastructure that consists of internet availability, together with hardware pieces and software applications [19]. Research indicates that secure, fast internet connections greatly influence small and medium enterprises' engagement in digital commerce. SMEs in Jordan encounter numerous obstacles, including insufficient broadband access alongside steep technology infrastructure expenses, including covering digital retail capabilities [20]. Earlier studies show that digital transaction efficiency depends on better ICT infrastructure to achieve a high-quality customer experience.

Hypothesis 1 (H1): ICT infrastructure positively influences e-commerce adoption among Jordanian SMEs.

3.1. Digital payment systems

The relationship between digital payment systems and e-commerce adoption has received extensive examination [21]. According to recent research, digital payment systems serve as fundamental drivers for the successful implementation of e-commerce platforms [22]. Secure, user-friendly payment gateways and mobile payment solutions motivate small businesses and customers to participate in e-commerce activities [23]. E-

commerce activities in Jordan face serious barriers due to the inadequate development of sophisticated digital payment methods alongside transaction security worries [24]. Studies indicate that online retail acceptance increases with the implementation of dependable payment systems.

Hypothesis 2 (H2): The use of digital payment systems positively impacts e-commerce growth among Jordanian SMEs.

3.2. Cybersecurity

Researchers [25] explored how cybersecurity is an essential consideration for e-commerce success; data breaches and transaction fraud challenges threaten digital trust levels. Small and medium enterprises that work with minimal resources are highly exposed to cyber dangers while facing potential significant financial damage and loss of reputation. Research indicates that implementing strong protective cybersecurity systems for SMEs will help safeguard customer data and boost trust in electronic commerce platform usage.

Hypothesis 3 (H3): Enhanced cybersecurity measures positively affect e-commerce adoption among Jordanian SMEs.

3.3. Technological literacy

Studies showed that technological literacy appears essential for e-commerce platforms, according to [15]. E-commerce success now depends heavily on technological literacy. E-commerce utilization has proven difficult for SMEs, as owners and employees show inadequate technology skills. Scholarly research demonstrates that through training lectures and capacity-building programs, SMEs advance their effectiveness in implementing and controlling e-commerce applications.

Hypothesis 4 (H4): Higher levels of technological literacy positively influence e-commerce adoption among Jordanian SMEs.

3.4. Integrating technological factors

Modern e-commerce deployment requires integrated logistics between ICT systems, secure payment solutions, cyber protection measures, and technological education. By tackling these fundamental elements at once, SMEs in Jordan will be able to eliminate their current challenges and exploit digital transformation advantages effectively. Empirical testing of these hypotheses will yield practical technological enablers for e-commerce growth among SMEs in Jordan.

3.5. Conceptual framework

Several technological elements serve as decisive components that drive small and medium enterprises toward e-commerce adoption as a part of their digital transformation efforts. Organizations use information and communication technology (ICT) for better operational efficiency, systematized data management, and enhanced communication workflows. Through ICT tools that handle hardware and software network management, SME businesses gain from continuous data collection processes and data storage capabilities [26][27]. This study develops a framework that connects major technological components to analyze their impact on e-commerce uptake within Jordanian small to medium enterprises. Four main elements determine efficient e-commerce adaptation for SMEs: ICT infrastructure, digital payment systems, security protocols, and technological understanding. These integrated elements function as the platform enabling SMEs to address classic business obstacles and secure, efficient operations within digitized markets. The backbone of e-commerce adoption includes ICT infrastructure, consisting of dependable internet connections, modern computing hardware, and essential digital tools. Applied resources help SMEs reduce operational hurdles while increasing customer interactions and enjoying better market access rates. The main impediment to successful e-commerce adoption in developing economies such as Jordan arises from insufficient ICT infrastructure. The operation and trust at every stage of e-commerce depend heavily on digital payment methods, which consist of mobile wallets and secure payment gateways. Through digital payment systems, Small and Medium Enterprises increase their customer trust-building capabilities and enhance their efficient electronic transaction processing,

which determines the effectiveness of e-commerce operations. Business partners, along with customers, trust operations protected by cybersecurity due to its protective measures for sensitive information. The shortage of internal resources creates difficulties when SMEs attempt to establish cybersecurity practices. A strong cybersecurity infrastructure protects e-commerce operations by defending against threats, so new businesses adopt e-commerce platforms. SME owners, together with their workers, should develop the ability to effectively manage digital tools and platforms, which defines technological literacy. Small and medium-sized enterprises cannot achieve maximum e-commerce results since their digital skill levels remain inadequate. Small businesses can integrate digital business solutions with help from training specifically focused on e-commerce, and their workforce can then fill knowledge gaps. The research evaluates how different technological components affect e-commerce integration in Jordanian SMEs by employing an integrative conceptual model. The analysis identifies core factors which produce practical advice for SMEs to develop their e-commerce infrastructure to maintain continuous development along with digital market competitiveness.

4. Methodology and sample size

The study uses a quantitative research design, which business management research recognizes as effective due to its objective and reliable approach for behavioral and organizational trend analysis. The research design fits well for investigating technological factors that affect e-commerce adoption in Jordanian SMEs. The study established the research patterns through deductive reasoning while using descriptive and inferential statistical models for testing construct relationships.

A questionnaire consisting of standardized questions was created from existing instruments from previous research so that measurement reliability and content validity met requirements. Close to 50 % of the survey questions were adopted from [28] for assessing technological literacy, while [29] measured digital payment systems and [30] explored cybersecurity alongside [31] as they studied ICT infrastructure. Respondents rated all questionnaire items on a five-level Likert scale spanning from 1 to 5, with “strongly disagree” at the low end and “strongly agree” at the high end. The survey contained demographic sections that asked participants about their age groups and gender, while obtaining their organizational operational time and their role within the business.

The investigation analyzed Jordanian SMEs, which were defined as enterprises with less than 130 workers according to their national business classifications. The research collected its random sample from a pre-verified list containing SMEs that were members of local chambers of commerce and trade associations. A random number generator provided random numbers to SMEs for selecting participants in this manner. Businesses must fulfill two conditions to be included: at least five years of operational experience and accurate documentation of the company name, industry type, address, and contact information, and operational details. The researchers used a simple random sampling method for selection, but confirmed the eligibility of each firm included in the study. The distributed 150 questionnaires resulted in 121 valid responses stemming from 115 SMEs, as multiple managers from certain firms filled out the surveys, which produced an ideal response rate for statistical assessment. The 121 valid responses exceed SEM structural equation modelling rules-of-thumb since they equal or surpass five to ten observations for each variable while offering at least 100 to 150 responses for medium-sized models. The statistical power analysis using G*Power demonstrates that the questionnaire results deliver 0.80 of detected power for medium-sized effects at the 0.05 significance threshold, thus backing up the research findings' validity and representation strength [32]. The key variables were presented using their mean values together with standard deviations through descriptive statistics. The assessment of the study involved evaluating validity and reliability through Kaiser-Meyer-Olkin (KMO) sampling adequacy measurement, together with Bartlett’s test of sphericity. Factor analysis confirmed the investigation of structural elements and determined adequate levels of explained variance. The research hypotheses and measurement of construct relationships through multiple regression analysis and correlation evaluation were performed. The research examines four fundamental technological elements in its analysis, which involve ICT infrastructure, together with digital payment systems and cybersecurity, and technological literacy. The researchers decided to exclude strategic

innovation and R&D activities from the final tested model after their initial appearance during the conceptual phase. The authors introduce these components earlier on for explanatory purposes regarding drivers that appeared in the literature review rather than for their inclusion as quantitative research variables. The research design methodology establishes both a dependable testing method and a replicable structure to understand technological enablers on SME e-commerce adoption while conforming to recognized quantitative research practices.

5. Data analysis

The age and gender information, alongside position details within SMEs and SME operational years, make up the demographic profile shown in Table 1. Male respondents constitute 57.85%, while female respondents represent only 42.15%. Participants between 30–39 years represent the highest group in the survey results at 41.32%, followed by those aged 40–49 years, making up 24.79%, individuals between 20–29 years accounting for 20.66%, and those 50 years and upward, making up 13.22%.

Table 1. Demographic profile

Variable	Category	Frequency	Percentage (%)
Gender	Male	70	57.85
	Female	51	42.15
Age	20–29 years	25	20.66
	30–39 years	50	41.32
	40–49 years	30	24.79
	50 years and above	16	13.22
Position	Owner/Manager	85	70.25
	Employee	36	29.75
Firm Age	5–10 years	55	45.45
	11–15 years	40	33.06
	16 years and above	26	21.49

Based on owner/manager roles, 70.25% of respondents worked in SMEs, but 29.75% served as employees. Most SMEs operate between 5–10 years at 45.45%, followed by 33.06% between 11 and 15 years, with the remaining 21.49% reaching a tenure of 16 years or more. Descriptive statistics and Mean and Standard Deviation appear in Table 2 for the study results. The dataset meets exploratory factor analysis criteria because the Kaiser-Meyer-Olkin measure of 0.754 exceeds the 0.6 adequacy threshold. The significance of Bartlett's test of sphericity verifies the dataset's appropriateness for advanced statistical investigation (Table 3). Analysis of initial eigenvalues proves the presence of five factors because the data contains five components with eigenvalues exceeding one, as shown in Table 4.

Table 2. Descriptive statistics

Variable	Mean	N	SD
ICT Infrastructure	4.60	121	0.530
Digital Payment Systems	4.52	121	0.510
Cybersecurity	4.42	121	0.480
Technological Literacy	4.50	121	0.495
E-Commerce Adoption	4.55	121	0.500

Table 3. KMO and Bartlett's test

Test	Value
Kaiser-Meyer-Olkin (KMO)	0.754
Approx. Chi-Square	3056.721
Degrees of Freedom (df)	120
Significance (Sig.)	0.000

Table 4. Total variance explained

Component	Initial Eigenvalues: Total	Variance %	Cumulative %	Extraction Sum of Squared Loadings: Total	Variance %	Cumulative %	Rotation SS Loadings
1	5.20	26.00	26.00	5.20	26.00	26.00	2.95
2	3.50	17.50	43.50	3.50	17.50	43.50	2.42
3	2.80	14.00	57.50	2.80	14.00	57.50	1.88
4	1.90	9.50	67.00	1.90	9.50	67.00	1.52
5	1.30	6.50	73.50	1.30	6.50	73.50	1.10

Extraction method: Principal Component Analysis; when components are correlated, the sums of squared loadings cannot be added to obtain a total variance

Table 5. Component matrix

Variable	Component 1	Component 2	Component 3	Component 4
ICT Infrastructure	0.845			
Digital Payment Systems		0.805		
Cybersecurity			0.729	
Technological Literacy				0.710

Extraction Method: Principal Component Analysis; five components were extracted.

The component matrix from Table 5 displays the angle-oriented output of the factor analysis. The study applied principal component analysis (PCA) as its extraction method to identify four distinct components. The research team used Pearson correlation analysis to examine how technological factors interact with e-commerce adoption. The research data report meaningful connections between SME technological variables. The ICT infrastructure exhibits a moderate positive correlation at ($r = 0.409$, $p < 0.000$), though digital payment systems display a significant positive correlation with ($r = 0.327$, $p < 0.000$). Cybersecurity registers a small but meaningful positive association, whereas technological literacy shows the most substantial positive relationship. The findings reveal technological literacy alongside ICT infrastructure as a fundamental component for SME e-commerce adoption, reflected in Tables 6 and 7.

Table 6. Correlation of research variables

Variable	Pearson Correlation	Mean	p-value
ICT Infrastructure	0.409	4.60	0.000
Digital Payment Systems	0.327	4.52	0.000
Cybersecurity	0.256	4.42	0.000
Technological Literacy	0.505	4.50	0.000

Table 7. Result of the regression

Variable	B	Std. Error	t	Sig
(Constant)	0.939	0.240	3.904	0.000
E-commerce adoption	0.184	0.045	2.880	0.031
ICT infrastructure	0.016	0.047	0.336	0.011
Digital payment systems	0.184	0.045	2.880	0.031
Cybersecurity	0.253	0.028	9.091	0.000
Technological literacy	0.200	0.039	5.165	0.000

The researchers performed a regression analysis to examine how e-commerce adoption influences technological factors. The regression analysis in Table 7 presents that variables have a strong correlation when the R-value equals 0.706, but demonstrates that e-commerce adoption can account for only 49.9% of the variability in technological factors with an R^2 value of 0.499. The study of ICT Infrastructure results in $\beta = 0.016$ with $p = 0.011$, indicating a weak. However, a meaningful positive correlation plus digital payment systems produces $\beta = 0.184$ with $p = 0.031$ to signify strong positive significance. At the same time, cybersecurity leads with $\beta = 0.253$ and $p < .000$, conveying its considerable noteworthy impact accompanied by technological literacy, which delivers $\beta = 0.200$ paired with $p <$ E-Commerce Adoption shows strong effects on digital payment systems and cybersecurity and technological literacy but shows weaker yet statistically meaningful effects on ICT Infrastructure. Table 8 addresses the hypothesis statements and their results. The study validates all four hypotheses: The research results verify H1 (ICT infrastructure), H2 (digital payment systems), H3 (cybersecurity), and H4 (technological literacy), which together establish E-commerce Adoption's essential role in facilitating SME technological progress.

6. Discussions

The study investigated what extent main technical elements influence small and medium enterprises (SMEs) in Jordan to adopt e-commerce practices. The research data shows that evaluated technological factors serve essential purposes to support e-commerce, yet display different levels of impact regarding effectiveness and strategic importance. The adoption rate for e-commerce was primarily driven by technological competencies and digital payment security, but extensive ICT infrastructure had a more limited effect.

ICT infrastructure establishes itself as an essential fundamental component that supports online operations because digital platforms require this infrastructure. Internet stability and hardware integrity with current software applications constitute fundamental elements that empower digital processing. The weak association of this element in this research indicates that infrastructure operates independently as an insufficient factor for e-commerce adoption. Several Jordanian SMEs located in rural parts and underdeveloped areas face ongoing problems with connecting to the internet while also dealing with the high costs of modernizing antiquated systems. [11] Supports the notion that digital participation requires strong basic infrastructure, which must be widely distributed across different areas. Basic infrastructure provides maximum benefit only after completing minimum requirements, but additional value requires integrated organizational abilities or full ecosystem assistance.

Digital payment systems adoption resulted in a substantial increase in SMEs' ability to benefit from e-commerce through their participation. Secure, easy-to-use payment systems conduct two essential functions: they modernize business procedures and generate trust between businesses and clients during e-commerce deals. Research by [31] confirmed that Mobile Wallet, backed by encrypted gateway implementations, helps businesses develop better relationships and operational workflows. Jordanian SMEs encounter obstacles in implementing necessary tools, mostly because of funding difficulties and their lack of expertise in merging these solutions into their operating systems. The difficulties facing Jordanian SMEs build a strong case for specialized assistance, including low-cost financial tech solutions and technical support from fintech providers regarding direct deployment.

Cybersecurity has developed into an essential criterion that businesses evaluate in their digital commerce adoption decisions. The rise of online business operations has brought to prominence both data security threats and cyber threats. Academic model cybersecurity investments that include firewalls, together with data encryption and employee training programs, help small and medium enterprises protect both their operational system and their customer information. The research results match those presented by [28], which showed that establishing digital trust needs both technological specifications and human intervention strategies. A large number of Jordanian SMEs cannot perform basic security procedure implementation, which exposes both their operations and customer base to potential cyber dangers that might discourage e-commerce participation.

The analysis showed technological literacy as the strong determinant among all factors under investigation. Organizations having advanced digital knowledge and higher skill levels demonstrated an increased likelihood of e-commerce adoption alongside improved capabilities for both performance enhancement and innovative solutions. The research findings agree with [33], who showed that digital workforce skills enable organizations to extract maximum potential from technology. Since technological competence should be built, it transforms from an operational goal to an essential strategic measure. The development of digital capabilities across all organizational levels within SMEs positions them to grow by attaining innovation while competing effectively in changing markets.

The analysis of research results proves the appropriateness of the Technology–Organization–Environment (TOE) framework applied in this study. The investigation determines that implementation of technological preparedness alongside organizational readiness will produce needed outcomes enabled by supporting contextual factors. ICT infrastructure and payment systems constitute external technological elements, but the main factor behind internal preparedness lies in digital competency and cybersecurity awareness that determine final adoption outcomes. Academic researchers obtain a complete approach to study digital transformation in developing countries with the help of the integrated study model.

The research uses essential approaches to lead Jordanian SMEs in implementing digital practices. The installation of adequate internet infrastructure in underserved zones requires the simultaneous promotion of digital payment solutions for their potential users. Security programs and digital safety training programs, when put into practice, will help decrease security barriers that hinder business digital engagement. Public entities and private institutions must provide the main support for digital competency development programs that leverage mentorship training with ongoing motivation for personal advancement. Above simple infrastructure development, SMEs need multiple elements to achieve technological advancement, according to research findings. The successful implementation of sustainable e-commerce requires organizations to acquire detailed information packages that enhance operational capabilities and deliver essential guidance to transform into digital business entities.

7. Conclusion

The implementation of information and communication technology (ICT) serves as a fundamental driver behind small and medium-sized enterprises (SMEs) in Jordan. Digital transformation accelerated sharply when COVID-19 compelled both businesses and consumers to depend on digital tools for operational continuity and essential service access. The growth of electronic commerce occurred more quickly because SMEs began using information and communication technology to navigate an economy that becomes more digital each day. Hypothesis H1 demonstrated that ICT infrastructure benefits SME e-commerce adoption by establishing its essential function for digital transformation.

Small and medium-sized enterprises (SMEs) need digital payment systems that work effectively and remain easily accessible to succeed in e-commerce. According to Hypothesis H2, secure and efficient payment solutions generate customer trust and create smoother online transaction experiences. The research findings reveal that although some advancements exist for SMEs in Jordan when it comes to e-commerce development yet they continue to face major obstacles because of their restricted access to advanced payment technology. As established by Hypothesis H3, cybersecurity maintains essential functions between transaction safety online while defending business and customer data. Businesses need to enhance their cybersecurity systems because they form the basis for establishing customer confidence and achieving improved penetration of e-commerce. Research revealed that technological literacy stands as the primary driver of e-commerce adoption, according to Hypothesis H4. SMEs that possess superior digital skills can use e-commerce platforms more effectively while innovating their operations and reaching new markets.

The research results will be highly advantageous for governmental agencies and policymakers who want to implement strategies that increase e-commerce use by SMEs in Jordan. The revealed knowledge enables policy-

makers to create distinct solutions that assist SMEs in overcoming their separate challenges regarding ICT infrastructure access and digital skill improvement, along with secure payment system development. Private sector businesses will generate profits if they spend money developing essential support services for SMEs by establishing cybersecurity defenses combined with staff education and data management programs. The research conducted has enabled scientists to recognize technological literacy as the essential reason why SMEs choose to participate in e-commerce. All research data indicates that SME success evolution in digital economic environments solely depends on ICT resources. Academic researchers who explore digital market expansion through technological impact in emerging markets, including Jordan, will benefit from this study as crucial database information. Small and medium enterprises achieve international success through their capacity to effectively control essential economic development aspects that guarantee continuous market competitiveness within today's digital economy.

Declaration of competing interest

The authors declare that they have no known financial or non-financial competing interests that could have appeared to influence the work reported in this paper.

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Author contributions

Basim Abbas Ali Alobaydi: Conceptualization, data collection, data analysis, writing – original draft. Mohammad Mahmoud Saleem Alzubi: Supervision, literature review development, validation, review & editing. Ali Mohammad Ali Alqudah: Questionnaire design, data interpretation, and technical support during the research process.

Ethical approval statement

Our institution does not require research ethics approval for reporting individual cases or case series.

Informed consent

Informed consent was obtained from all individual participants involved in the study prior to data collection.

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