

User experience and continuous use of block-chain technologies among freight forwarding firms in Ghana: a mediated-moderation model

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Abstract

Purpose – This paper investigates the mediated-moderation roles of adhocracy culture (ADC) and business ecosystem learning between user experience (UX) and continuous use of block-chain technologies (CUBT) among freight firms in Ghana.

Design/methodology/approach – A stratified sampling technique was used in the selection of 327 employees of freight firms. This paper employs regression analysis to examine the hypothesized paths.

Findings – The findings show that ADC moderates the partially mediated role of the business ecosystem between technology UX and CUBT.

Research limitations/implications – Based on the cross-sectional design adopted, the study findings do not reflect the changing dynamics of employees of freight firms over a long period of time in Ghana.

Originality/value – This research is one of the first in maritime transport literature to explore the relevance of block-chain technologies among freight firms in an emerging economy.

Keywords User experience, Adhocracy culture, Business ecosystem learning, Continuous use, Block-chain technologies, Maritime transport industry

Paper type Research paper

1. Introduction

Globally, the deployment of block-chain technologies (BCT) for cargo and freight management at seaports is rapidly gaining attention among researchers and practitioners in contemporary times (Alnıpak and Toraman, 2024; Hirata *et al.*, 2021). These trends may be attributable to the quest for seaport operations to be harmonized and managed through a single data processing unit. Consequently, a number of seaports have rolled out synergized technological offerings such as Maritime Single Window to address freight and cargo-related operational issues (Peynirci, 2023). Nonetheless, the deployment of BCT at seaports is a multifaceted operational strategy that requires cooperation among key stakeholders such as freight firms. This collaborative transition is intentioned to convert traditional responsibilities of seaports from being just cargo facilitators to intermodal freight hubs with fully synchronized information systems to manage large volumes of data (An, 2024). To remain viable in the face of digital transition at seaports, freight firms must embrace the adoption of digital technologies. The current study adds that the uncontrollable nature of digital evolution within the maritime transportation industry makes it incumbent for freight firms to embrace learning cultures that are adaptive. Furthermore, freight firms must build innovative information and communication technology capabilities through relational embeddedness. According to the stimulus-organism-response (S-O-R) theory (Mehrabian and Russell, 1974), firms are obliged to respond to external stimuli with internal capabilities. Thus, the study asserts that firm culture is an essential pillar that may ward off threats of rapid digital evolution to deliver operational efficiency among freight firms.



Research in maritime transportation and organizational management literature extols the importance of understanding the means through which the adoption of BCT influences firm outcomes such as innovativeness and efficiency (Ahmad *et al.*, 2021). Nevertheless, very little evidence of prior studies highlights key determinants that influence the nexus between BCT adoption and continuous use among freight firms. It is imperative to add that prior studies that attempted to address gaps in the literature regarding the adoption of BCT among freight firms posit that the concept is at its nascent stage (Chavalala *et al.*, 2024; Orji *et al.*, 2020), hence the need to explore firm capabilities that may promote or impede its continuous use. Also, scholars in several fields of study, including health services and financial institutions, have explored the adoption of BCT (Shinde *et al.*, 2023; Wu *et al.*, 2024); however, the application of the technology in routine task operations of freight workers remains unclear.

The study argues that current literature on block-chain adoption in maritime transportation and organizational management literature has not satisfactorily addressed present-day strategic fits and their concomitant issues among workers of freight firms, particularly in Africa. Thus, this paper examines the ways in which block-chain adoption has shaped the operational efficiency of freight firm workers in Ghana. Further, the study assesses the mediated-moderation roles of adhocracy culture (ADC) and business ecosystem learning (BEL) within a context. This paper is grounded in both S-O-R theory and technology-organization-environment (TOE) model. The study boasts three distinct contributions. First, the study advances knowledge on both maritime transportation and organizational management by moving beyond traditional ways of data management among freight firms at seaports. Specifically, the study extends the cognitive scope of knowledge through the examination of block-chain user experience (UX) for operational efficiency among freight firm workers. Accordingly, the study highlights the value of BCT in enhancing logistics and cargo management by freight firms (Xu and He, 2022). Second, the study extends knowledge on the importance of leader styles that promote firm cultures that are flexible and innovative in order to optimize the operational efficiency of freight firms (Sindakis *et al.*, 2024). Third, by giving consideration to social networking, the study highlights the capacity of relational embeddedness to deliver digital literacy among employees of freight firms (Shen *et al.*, 2024). Accordingly, the study projects a task strategy that touts BCT as an affordance for reshaping task redesign of employees of freight firms in a rapidly changing world of maritime transport.

2. Literature review and hypotheses development

2.1 Block-chain technologies and the context of the study

Even though the invention of BCT predates 2 decades, its prominence as a digital affordance has not declined in both academic and practitioner applications. In Ghana, the central government has rolled out BCT to curb fraud and corruption-related issues in land administration (Mintah *et al.*, 2021), banking operations (Asante Boakye *et al.*, 2022), as well as, data management of cargo and freight services at seaports (Senyo *et al.*, 2021). Nevertheless, the study notes that the adoption of BCT at Ghana's seaports has been plagued with several implementation hiccups. Some notable implementation challenges faced at Ghana's ports include the emergence of new cybersecurity threats, consequently raising distrust concerns between freight firms and cloud computing services (Senarak, 2024). Also, freight firms' misconceptions of digital terminologies such as "block-chain" and "Internet of Things" have significantly contributed to hostility towards the adoption of technological tools in the maritime transportation industry in Ghana (Brunila *et al.*, 2021; Crowther, 2023). Lastly, freight firms resist digital technologies due to the cost implications of acquiring automation and robotics, as well as human capital training and productive hours lost due to capacity building (Inkinen *et al.*, 2021). In the face of these challenges, Ghana is seen as a beacon of Africa in terms of the successful implementation of BCT in its public institutions such as the seaports (The Block, 2024).

2.2 Stimulus-organism-response and technology organization environment: an integrated approach

The current study is grounded in both S-O-R theory and TOE. The S-O-R theory draws its cognitive underpinnings from a combination of internal and external environmental determinants that affect business entities' operations. [Mehrabian and Russell \(1974\)](#) assert that the S-O-R framework helps elucidate the means by which organisms facilitate connections between stimulation and response. Specifically, the S-O-R theory is underpinned by three key elements, that is, stimulus, organism and response ([Tang et al., 2015](#)). Stimulus is a description of an influence element in an external environment that has the propensity to change a person's intellectual state ([Lin and Lo, 2016](#)). "Organisms" relate to internal elements that cause variations in a person's affective and intellectual conditions owing to some intriguing factors ([Yu et al., 2021](#)). Lastly, "response" in the model reflects a person's attitude and its corresponding effect on behavior ([Mehrabian and Russell, 1974](#)). Extant literature extols the prowess of S-O-R to predict employees' behaviors such as learning, value creation and dexterity ([Duong and Nguyen, 2024](#); [Wang et al., 2024](#)). Nevertheless, the S-O-R theory has been critiqued by scholars for its oversimplification and limited specificity of complex dynamics inherent in a multifaceted business world ([Rajput and Gahfoo, 2020](#); [Xu et al., 2022](#)). Based on these criticisms of the S-O-R theory, this study advances its scope by incorporating the assumptions of TOE ([Tornatzky et al., 1990](#)) to provide context specificity.

TOE deploys three main factors that influence sustainable digital technology adoption. First, technology refers to how digital tools such as BCT offer affordances that are perceived to be useful to users. Technology in the framework encompasses the development of field-tailored specific requirements of block-chains that help satisfy peculiar demands of freight firms for operational efficiency ([Sodhi et al., 2022](#)). Second, the organizational context relates to internal resources such as leaders dynamic capabilities, creation of an innovative firm culture and structural support for employees. These firm controllable factors promote easy adoption and continuous use of block-chain technologies (CUBT) among freight firms ([Chavalala et al., 2024](#)). Third, the environmental context refers to uncontrollable factors that pose either threats or provide opportunities for freight firms in the use of BCT. Uncontrollable factors that enhance or impede block-chain adoption among freight firms include dealing with hyper-competitive pressures and trust issues among key collaborators ([Orji et al., 2020](#)). Thus, the study extends S-O-R theory with TOE theory to elucidate the importance of context specificity in BCT adoption among freight firms in Ghana.

2.3 User experience and continuous use (CU) of block-chain technologies (BCT) for efficiency

Block-chain is a common network platform that facilitates transactions among parties with rights of authority not clothed with a single principal. With the reliance on existing technologies such as cryptocurrency, BCT integrates a pool of databases, which can be simultaneously accessed by parties through a trustworthy medium ([OECD, 2018](#)). This decentralized transmission mechanism records all data reviews and updates to the primary document in real time, guaranteeing absolute transparency ([Christodoulou et al., 2024](#)). By extension, UX is a comprehensive term that describes all facets of a user-service interaction ([Alben, 1997](#)). [Sheng and Teo \(2012\)](#) argued that UX is a term that originates from a book entitled "*Experience Economy*". The scholars opined that "experience" is an economic gift received after the consumption of goods and services. Thus, the concept acts as a benchmark that evaluates a user's desirability and reality in the consumption of a product. It is noteworthy to add that improved UX may lead to user acceptance and continuous use of a product ([Callari et al., 2024](#)). Context-wise, the study adopts the "technology UX" (TUX) framework ([Jang and Han, 2022](#)) to explain freight firms' adoption of BCT. Scholars opine that socio-economic values and trustworthiness evident in a business environment constitute critical factors that shape a user's experience with digital tools. Accordingly, the current study deploys the

assumptions of TOE (Tornatzky *et al.*, 1990) to elucidate on the cognitive link between UX and CUBT among freight firms.

Continuous use of technology refers to a user's cognitive judgment and behavioral intention towards a digital tool (Hevi *et al.*, 2024). A user's cognitive judgment is a product of experiences garnered through user-technology interactions within a business environment (Pei *et al.*, 2023). Drawing from the "technology UX" framework (Jang and Han, 2022), the study notes the relevance of social values such as business ecosystem relational embeddedness as a major determinant of CUBT. For economic values, the study highlights the need for freight firms to continuously use BCT to create value. Lastly, technology value under the framework relates to digital characteristics such as information security that promote confidence and trust among BCT users. Prior studies have established a positive link between UX and continuous use of digital technologies (Yang *et al.*, 2022; Yuen *et al.*, 2022). On the basis of these arguments, the study hypothesizes that

H1. TUX will positively influence the CUBT.

2.4 Mediating effect of business ecosystem learning (BEL)

BEL is a process of knowledge acquisition through relational embeddedness within a firm's industry (Boxu *et al.*, 2022; Zhang *et al.*, 2022). BEL is a concept that thrives on both informal and formal learning. Despite its theoretical grounding, the concept has not received much research attention (Huber, 2019). Consequently, the examination of BEL as a mediating variable in organizational literature is limited. Notwithstanding this gap in literature, closely related terms to BEL such as relational embeddedness have been explored as a mediator in organizational studies. For example, Ariadi *et al.* (2021), in an empirical paper, conclude that relational embeddedness through strategic supplier and customer integration mediates lean supply chain strategies and firm performance. In the current study, BEL is contextualized as both informal and formal learning that takes place between freight forwarding firms, governmental agencies in charge of freight and cargo, as well as regulatory actors in the maritime industry.

The study draws on the S-O-R theory (Mehrabian and Russell, 1974) to explain the links between BEL and favorable behavioral intentions towards digitalization. The theory posits that learning from industry actors in a firm's ecosystem is a prerequisite for the development of emotional and intellectual capabilities (Olfat *et al.*, 2022). The scholars add that a person's emotional and intellectual capabilities may change due to dynamism in a firm's ecosystem, consequently manifesting in behavior modification. Context-wise, the understanding of BEL through cognitive assumptions of S-O-R theory is deemed imperative in explaining learning culture and digital capacity building among employees of freight firms in Ghana. Empirical studies have established a significant indirect effect of BEL between UX and continuous use of technology among employees of freight firms (Swierczek, 2023; Tang *et al.*, 2023). This suggests that BEL indirectly and positively links TUX and the CUBT. Consequently, the paper hypothesized that:

H2. Business ecosystem learning mediates between TUX and CUBT.

2.5 Moderating role of adhocracy culture (ADC)

Extant literature has shown that adhocracy organizational culture (OC) is a major predictor of workers' continuous use of digital technologies. The term OC is used to describe a firm's value systems that serve as guiding principles for desired behaviors and norms among workers (Momos and Tsuma, 2020). It comprises intensely embedded patterns of behavior that reflect shared expectations, standards and philosophies among employees in a firm. Thus, OC considerably influences thought processes, attitudes, design procedures and results (Ma *et al.*, 2023). The current study contextualizes OC from the perspective of the adhocracy cultural dimension by Cameron and Quinn (1999). The study argues that despite 4 main dimensions

(clan, adhocracy, market and hierarchy) established by the scholars, characteristics of ADC such as the development of risk-taking behaviors and creativity among employees are best fitted to describe firm norms that promote flexibility, adaptability and novelty. Also, ADC is said to be positively linked to change-related concepts such as learning, creative thinking and competency development (Ismail, 2024; Shea *et al.*, 2023).

The current study draws on both S-O-R and TOE theories to explore the moderating role of ADC among workers of freight firms. These assertions are grounded in the capacity of ADCs to promote workers' agility towards the adoption of BCT. Although related prior studies highlight the relevance of ADC in advancing the adoption of BCT among firms (Long *et al.*, 2022; Pantouvakis and Vlachos, 2020), it fails to sufficiently address the use of relational embeddedness for capacity building for continuous use of digital technologies. This study explores this gap in literature by exploring the moderating role of ADC between BEL and CUBT. Therefore, the study conjectures that

H3. ADC moderates the link between business ecosystem learning and CUBT.

3. Methodology

3.1 Participants and procedure

The study examines the hypothesized model linking UX, ADC, BEL and CUBT among employees' of freight firms in Ghana. Specifically, a survey was undertaken in 5 cities in Ghana, namely, Tema, Accra, Takoradi, Elubo and Aflao. The target population of the study was field operational employees of freight forwarding firms between the months of April and July 2024. A disproportionate stratified sampling method was used in the distribution of 370 questionnaires, with 327 valid responses retrieved, denoting an 88.4% response rate. Also, the study employed the services of eight trained enumerators. The enumerators received training on ethical dilemmas in undertaking an academic research. Precisely, matters relating to assurance of unrecognizability and concealment of participants' responses were made the topmost priority. Respondents used approximately 27 min to fill the questionnaires.

In resolving any likely challenge that may emerge in the dataset analysis, some initial valuations were undertaken. First, 30 faculty members with expert knowledge in management and logistics were surveyed to pre-test the questionnaire (Preneger *et al.*, 2014). The pre-tested outcomes revealed that items on all constructs met Cronbach's alpha tolerability threshold (α -value >0.70). Second, the paper wards off any latent challenges that may pose a threat to the credibility of the data via common method bias. This latent cross-sectional data problem was addressed through the deployment of the Harman single factor test (Podsakoff *et al.*, 2003). Consequently, it was unearthed that no single factor "variance explained" was above the threshold value of 50%. Lastly, the paper wards off any potential non-response bias by crafting each statement on the questionnaire succinctly.

3.2 Measures

A five-point Likert-type scale, with anchors (1) strongly disagree to (5) strongly agree, was used in the collection of responses. The scales are described.

Block-chain TUX. A nine-item scale developed from Jang and Han (2022) "technology UX" framework was used to survey the respondents. Context-wise, TUX refers to digital affordances that deliver socio-economic and technological values to employees of freight firms in Ghana. A scaled item reads, "Data security of BCT for freight and cargo services is very important to me".

ADC (OCAI). A six-item scale adapted from Cameron and Quinn (1999) was used. Context-wise, ADC describes firms' norms that value and promote creativity, risk-taking and innovativeness. A scaled item reads, "My colleagues and I are ready to stick our necks out for risk-taking".

BEL. A 10-item scale adapted from Tsou *et al.* (2018) was used. Context-wise, BEL describes employees' formal and informal interactions with stakeholders as a source of capacity building for process innovation. A scaled item reads, "We have a higher degree of close work relationship with our partners".

CUBT. A three-item questionnaire adapted from Wu and Chen (2017) was used in the study. Within context, CU of BT describes freight firm employees' intention to incessantly use BCT due to their routine job experiences. An item on the questionnaire reads, "I will always use block-chain platforms for my daily operational tasks".

4. Results

4.1 Psychometric properties of measures

Exploratory factor analysis (EFA) was conducted with a programmed eigenvalue set above 1 to test the scales. EFA scores regarding TUX, ADC, BEL and CUBT met the appropriateness threshold score of 0.07 (Hair *et al.*, 2017). Accordingly, 21 out of 28 items loaded satisfactorily. The dataset was subsequently tested for robustness to establish goodness-of-fit (Hair *et al.*, 2010) (see Table 1).

4.2 Sampling adequacy tests

Kaiser–Meyer–Olkin (KMO) and Bartlett's test of sphericity are primary valuation processes that are used in determining sampling precision when performing EFA. KMO figures must range between 0 and 1 to be deemed acceptable. Additionally, Bartlett's test values must be less than 0.05 to be estimated as suitable. The KMO scores of the study's dataset are as follows:

Table 1. Factor analysis, reliability and composite reliability of constructs

Factor measurement	Loadings	Variance exp. (%)	R	CR
Continuous use of BT ($\alpha = 0.851$)		23.178		0.930
CUBT3	0.853		0.824	
CUBT1	0.845		0.902	
CUBT2	0.821		0.798	
Technology user experience ($\alpha = 0.883$)		16.533		0.946
TUX8	0.871		0.884	
TUX1	0.814		0.908	
TUX7	0.799		0.775	
TUX5	0.780		0.842	
TUX4	0.733		0.902	
TUX2	0.732		0.837	
Business ecosystem learning ($\alpha = 0.769$)		14.624		0.943
BEL3	0.839		0.904	
BEL4	0.822		0.842	
BEL1	0.749		0.878	
BEL9	0.743		0.894	
BEL8	0.721		0.785	
BEL5	0.719		0.897	
BEL7	0.712		0.886	
Adhocracy culture ($\alpha = 0.818$)		11.590		0.935
ADC4	0.824		0.824	
ADC6	0.803		0.891	
ADC2	0.791		0.904	
ADC1	0.779		0.898	
ADC3	0.725		0.892	

Note(s): KMO = 0.841, Bartlett's test of sphericity: $\chi^2 = 7914.194$, $p < 0.000$

Source(s): Field survey by the author (2024)

TUX, ADC, BEL and CUBT = 0.841, which explained 65.925% of the change in the model. The *p*-values of Bartlett’s test of sphericity (*p*-value sig of 0.000 < 0.05) were significant for all constructs. These tests point to the appropriateness of the dataset’s sampling suitability (see Table 1).

4.3 Reliability, validity and correlation analysis

Internal consistencies of the construct scales were assessed through Cronbach’s alpha and composite reliability (CR) valuations. Nunnally and Bernstein (1994) posit that Cronbach’s α -value >0.70, whereas CR α -value >0.80. Each construct loaded significantly; TUX = (α 0.883, CR 0.946), ADC = (α 0.818, CR 0.935), BEL (α 0.769, CR 0.943) and CUBT (α 0.851, CR 0.930). This implies that all constructs had good reliability and CR. Also, convergent validity was established owing to each construct’s average variance extracted (AVE) gaining an acceptable α -of >0.5. Additionally, discriminant validity was established as the square roots of each construct’s AVE were higher than the correlations among the constructs (Fornell and Larcker, 1981) (see Table 2).

4.4 Measurement and structural model

The statistics measurement model indices are as follows ($\chi^2 = 445.834, df = 284, p = 0.001$); root mean square error of approximation = 0.001; comparative fit index = 0.998; Tucker–Lewis index = 0.997 and standardized root mean square residual = 0.002, indicating good fit of the model. This result is an indication of the statistical robustness of the study’s model in readiness for further inferential statistics.

4.5 Demographic characteristics and test of normality

Demographic characteristics in the study comprise gender, age, educational level, employment type and number of years with employer. To the specifics, gender was dominated by males with 74.0%. The age range with most representation is the 38–47 bracket, with 35.8%. Most of the respondents with a percentage of 66.4 belong to the non-tertiary educational level classification. With a percentage of 88.4%, the employment type was dominated by full-time workers. Finally, regarding the number of years with employer, most of the respondents, constituting 59.6% were categorized under over 5 years. Also, descriptive statistics of the variables’ mean scores and standard deviations were tested (see Table 2). Further, Kolmogorov–Smirnov and Shapiro–Wilk’s tests were undertaken to assess the normal distribution of the dataset. The test reveals that *p*-values for each construct surpassed the benchmark α -value of 0.05 (Pallant, 2007), indicative of a normal distribution curve. Finally, challenges that may arise as a consequence of multicollinearity were resolved via the deployment of correction coefficients ($\alpha < 0.80$) (Hair et al., 2010).

Table 2. Mean, SD, reliability measures and inter-correlation for constructs

Items	CR	AVE	1	2	3	4
Technology UX	0.946	0.624	<i>0.790</i>			
Business ecosystem learning	0.943	0.577	0.193**	<i>0.759</i>		
Adhocracy culture	0.935	0.616	0.209**	0.177**	<i>0.785</i>	
Continuous use of BT	0.930	0.705	0.394**	0.414**	0.306**	<i>0.840</i>
Mean			3.760	3.978	2.633	3.426
SD			0.719	0.692	1.206	0.723

Note(s): SD = standard deviation, AVE = average variance explained and CR = composite reliability. All inter-correlation coefficients are significant at **p* < 0.05 and ***p* < 0.01. Italic diagonal figures represent the square root of the AVE; sub-diagonal figures are the latent construct for inter-correlations

Source(s): Field survey by the author (2024)

4.6 Mediated-moderation model

With the aid of Hayes' Multiple Regression Model 14, the paper examines the mediated-moderation model of the study constructs (see Table 3 and Figure 1). First, the finding reveals that TUX predicts BEL ($b = 0.167, SE = 0.053, t(327) = 3.174, p < 0.01$) and CUBT ($b = 0.327, SE = 0.039, t(327) = 8.330, p < 0.001$), confirming H2a and H1. Also, BEL positively predicts innovative capability ($b = 0.267, SE = 0.109, t(327) = 2.462, p < 0.05$), confirming H2b.

Second, the paper found BEL to mediate between TUX and CUBT. The mean estimate of the indirect effect of TUX on CUBT via BEL was ($b = 0.019, SE = 0.008$) [CI 95%: Lower Limit (LL) 0.005, Upper Limit (UL) 0.039]. Therefore, the indirect effect of BEL was significant, signifying the mediating effect of BEL between TUX and CUBT, confirming H2.

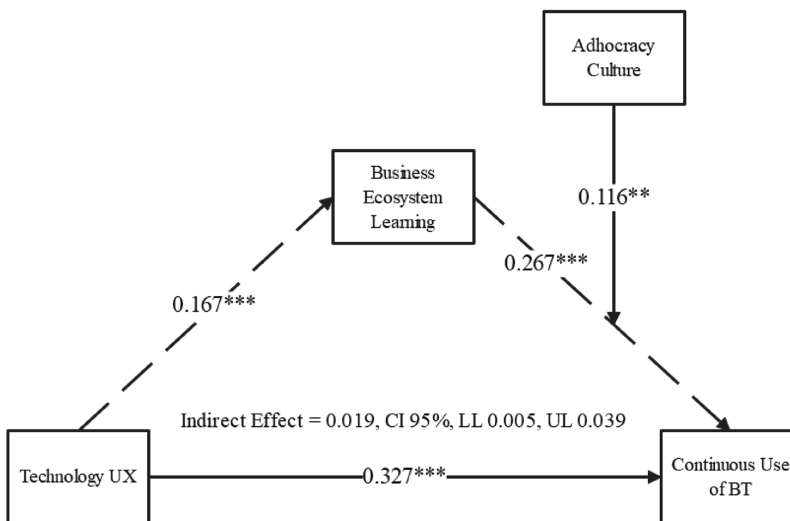
Third, the study explores the moderating effect of ADC. Precisely, the assessment was conducted to establish linear and interaction effects of BEL and ADC. Accordingly, the interaction term BEL*ADC positively predicts the relationship between BEL and CUBT ($b = 0.116, SE = 0.039$ and $t(327) = 2.956, p < 0.01$), confirming H3. Also, conditional and total effects from BEL to CUBT were tested against definite moderator values of ADC ($M \pm 1$

Table 3. Indirect effects of technology UX on continuous use of BT via business ecosystem learning at ± 1 SD of adhocracy culture (N = 327)

Business ecosystem learning	b	BootSE	BootLLCI	BootULCI
-1 SD	0.064	0.025	0.021	0.117
M	0.083	0.030	0.028	0.146
+1 SD	0.122	0.044	0.042	0.213

Note(s): BootLLCI and BootULCI = Lower level and upper level of the bias-corrected and accelerated bootstrapped confidence interval for = 95%; bootstrapping resamples N = 5,000

Source(s): Field survey by the author (2024)



Note(s): Straight lines = Direct effects, Dotted lines = Indirect effects

Source(s): Field survey by the author (2024)

Figure 1. Tested research model

SD). The result shows that all indirect effects were significant within $\pm 1 SD$. This specifies that the estimation of CUBT by BEL is probable within the ADC range of $M \pm 1 SD$ and that the indirect effect from BEL to CUBT is higher for employees with a high inclination to ADC compared to employees with a low proclivity to ADC (see [Figure 1](#)).

5. Findings and discussion

This paper explores direct and indirect effects between TUX, ADC, BEL and CUBT among employees of freight firms in Ghana. First, the study results reveal that TUX has a positive effect on the CUBT. This result implies that a firm's equilibrium is modified when work designs and techno-structural changes are affected. Specifically, a firm's adoption of BCT constitutes a paradigm shift from traditional to contemporary methods of delivering routine work activities. Thus, a firm must develop and design a variety of learning methods in response to these techno-structural changes. This result draws empirical backing from related prior findings that have rationally established that if a firm undertakes a planned change of digital transformation, then its employees' intellectual capacities must be enhanced through training and development ([Cheng et al., 2023](#); [Koh et al., 2022](#)). Second, TUX positively predicts CUBT among freight firms in Ghana. This result implies that UX provides the analytical grounds for employees of freight firms to make subjective judgments on the ease of use and usefulness of BCT. This cognitive assessment weighs user expectations against actuals for the determination of CUBT among freight firms. This outcome validates related studies undertaken by [Yang et al. \(2022\)](#) and [Yuen et al. \(2022\)](#).

Third, BEL positively predicts CUBT among freight firms in Ghana. This implies that knowledge acquisition through relational embeddedness helps freight firms to easily adapt to digital transformation at seaports. Thus, business ecosystem reliance is a major intellectual capacity development hub for key players within the maritime transportation industry. This finding validates erstwhile studies undertaken by [Swierczek \(2023\)](#) and [Tang et al. \(2023\)](#), where a positive link was established between learning through relational embeddedness and continuous use of digital technologies.

Next, the result shows that BEL mediates between TUX and CUBT. This finding emphasizes the role of relational embeddedness in knowledge acquisition and capacity building for digital competency among freight firms in Ghana. The finding projects that the relationship between TUX and CUBT could be given meaning by freight firms' desire for digital knowledge acquisition through stakeholder interactions within the seaport ecosystem. This outcome gives credence to previous empirical findings undertaken by [Cheng et al. \(2023\)](#) and [Rehman \(2023\)](#), where both studies established the importance of digital knowledge acquisition through relational embeddedness. The capacity of BEL to mediate between TUX and CUBT is given cognitive credence in the S-O-R theory. The S-O-R theory posits that a firm's external environment offers incentives and opportunities that ignite spontaneous intrinsic emotional reactions, which may lead to behavior modification ([Hameed et al., 2022](#)).

In the assessment of the moderating effect, the result explains that the interaction term "BEL*ADC" moderates between BEL and CUBT. In effect, this suggests that ADC is a major determinant of CUBT for data management among freight firms in Ghana ([Senyo et al., 2021](#)). This implies that value systems of firms that are modeled on a variety of innovative learning approaches such as self-initiated artificial learning may positively influence the CUBT among freight firms. This outcome is corroborated by related empirical findings, which have rational evidence that if firm culture is built on the desire for knowledge acquisition, then firms are likely to rapidly adapt to the fast-paced digital evolution in the maritime transportation industry ([Inkinen et al., 2021](#)). Furthermore, the study outcome is given credence by characteristics of ADC, which touts learning, risk-taking behaviors, intellectual stimulation and employees' creative efficacy as crucial in determining digital sustainability at seaports. This outcome renders empirical support to prior works, where ADC was proven as a moderator between UX and continuous use of digital technologies ([Long et al., 2022](#); [Pantouvakis and](#)

Vlachos, 2020). Hence, it is cogent to state that the capacity of “BEL*ADC” to moderate between BEL and CUBT could be explained by freight firms’ ambidexterity, agility and leadership competencies (Chavalala *et al.*, 2024).

6. Recommendations and conclusions

Results of the paper suggest that the digital transformation of port services, particularly to third parties such as freight forwarding firms in Ghana, has been significantly enhanced. Nevertheless, in West Africa, volumes of cargo and freight have been on the decline in contemporary times, with Ghana and Nigeria being the worst affected (Shibuya *et al.*, 2023). This research suggests that improvements were required in a number of areas, such as freight firms’ cultural orientation, knowledge acquisition through stakeholder collaborations and building a positive culture towards digital innovation among all players. The paper makes several worth mentioning theoretical and practical recommendations to advance port services in Ghana. These recommendations could be deployed as process elements to enhance digitalization at Ghana’s ports to achieve effective implementation of the “Maritime Single Window” Initiative.

First, the study theoretically extends literature on the intellectual boundaries of S-O-R theory by incorporating contextual specificity (TOE) into its practical application. The research makes a scholarly claim that although freight firms are obliged to respond with internal capabilities to digital evolution in the maritime transport industry, it is important for these firms to do so within specific domains of the TOE framework. Second, the study advances the intellectual understanding of TOE theory through the validation of its quantitative measurement among workers of freight firms.

For practical implications, the investigation reveals that firm culture is a major antecedent of promoting digital transformation in the maritime industry. Thus, it is incumbent on third-party stakeholders such as freight firms to embrace cultures that are adaptive, creative and receptive to individual initiatives in an industry that is experiencing fast-paced technological evolution. Accordingly, freight firms must discard traditional methods of logistics operations, in favor of building digital structures, systems and intellectual capital to take full advantage of contemporary dynamics in the maritime industry. Second, the paper highlights the relevance of knowledge sharing and technical capacity building among key actors within the maritime industry. Consequently, the role of social networking among freight firms and other collaborators in the maritime industry has been entrenched as a catalyst for sustainable digital transformation. The paper encourages managers of freight firms to institutionalize informal learning engagements as the primary source of idea incubation and development. Also, employees must be encouraged to build intellectual and technical competences through social networks. Accordingly, freight firms could enact internal policies and operational procedures that optimize relational embeddedness with seaport officials, regulators, competitors and customers for the purposes of continuous improvement.

7. Limitations and areas for future study

Despite several pertinent recommendations made in this paper, there are few methodological limitations necessitating the need for further investigation of the phenomenon. The current study illuminates the theoretical concepts of TUX, ADC, BEL and CUBT through the S-O-R and TOE theoretical lenses. Nevertheless, the paper predominantly focused on inferential analysis of the study variables. Consequently, the paper was limited in delivering narrations that provide an in-depth understanding of maritime transportation ecosystem dynamics. Future studies should explore the phenomenon from an interpretivist’s paradigm. Also, the architecture of the paper is grounded in cross-sectional design. Although it is an efficient research design, it fails to take into account changing dynamics of events and corresponding variations in respondents’ opinions over a long period. Future scientific inquiry on this phenomenon should be explored through the deployment of a longitudinal research design.

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