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Empirically tested indigenous supply chain resilient framework for future businesses

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Abstract

The issues of resilience contribute significantly to a sustainable supply chain of goods and services coming through the main ports of entry and this is crucial for the survival of many industries, organizations and customers in the World, the African continent and the Sub-Sharan region. Thus, sustainable supply chains rely heavily on information communications technologies (ICT) to perform their operations. The resilience of these ICT processes ensure that these goods and services are delivered to satisfy customers without compromising quality. The ICT that enables the sustainable supply chain performance has to be responsive, reliable and efficient. This quantitative study of two hundred and fifty (250) respondents investigates the influence of ICT (agility, reliability and efficiency - ICTARE) on economic sustainable supply chain performance (ESSCP) and the mediated effect of robust competence of IT staff between ICTARE and ESSCP. Lisrel 8.0 was used to analyze the data obtained from the respondents. The study results suggest a positive relationship between ICTARE and ESSCP. The results also confirm a full mediation between ICT reliability and sustainable supply chain performance through ICT staff competence within the context of shipment of goods and services within Ghana's ports and harbours. The implication of this research is enormous: ICT used in a suitable way will enhance the resilience of supply chain networks in supporting the distribution of goods and 'services in a timely manner' in order to improve customer satisfaction.

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Agility
Competent IT staff
Economic sustainable supply chain performance
Efficiency
Reliability
Resilience.

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1. Introduction

The idea of ICT resilient supply chain research has received critical attention due to a wide range of recent high-profile catastrophic and disruptive events, such as strikes, arson, terror attacks, tsunamis, fire outbreaks, floods, pirates, and earthquakes, which are ravaging both lives and properties (Betto & Garengo, 2023). These recent global events have invoked a call for effective resilience researchers to address the design of supply chains to prepare, detect, mitigate, recover, and transform supply chains. These events underscore the importance of building supply chains that are resilient against unexpected disruptions, in that, the consequences of these disruptions can be severe, as evidenced by various instances. These events emphasize that the global supply chain function is evolving and has entered an era of turbulence (Qadri et al., 2024) from which the import-export companies are not exempt. Supply chain disruptions can have a negative significant impact on the normal course of business operations of the focal firm, leading to reduced efficiency, increased costs, delayed delivery times, and lost revenue (Wang & Yang, 2021). The outbreak of COVID-19 has increased resilience research, and digital technology applications have proven to enhance the supply chain digital resilience of people and organizations (O'Leary, 2020; Rodríguez-Espíndola, Chowdhury, Dey, Albores, & Emrouznejad, 2022). Import and export businesses are crucial for the world economy; and they are responsible for global economic growth and expansion, exchange of goods, capital, investment, technology and knowledge. Ports and Harbours supply chains are exceptional and dissimilar from manufacturing and 'other industrial supply chains'; hence more attention should be given to them to minimize the occurrence, spread, and impact of disruptions that affect the Ports and Harbours industry. Researchers have contended that cross-border businesses must fashion sustained competitive advantages by concentrating on capabilities to promote growth, survive disruptions, and sustain their businesses (Essuman, Boso, & Annan, 2020). The application of digital resilience technologies at the peak of the COVID-19 pandemic enabled the sharing of vital information to minimize the spread, impact, and mitigation costs within local and international communities (Chakma, Li, & Kabuhung, 2021). ICT 'resilience' is defined as the 'adaptive capability of a supply chain to prepare for and/or respond to disruptions, to make a timely and cost-effective recovery and therefore progress to a post-disruption state of operations, ideally a better state than prior to the disruption (Tukamuhabwa, Stevenson, & Busby, 2017)'. Thus, 'resilience capabilities' will enable firms, in this case, import-export businesses to prepare and respond to predictable and unpredictable disruptions by ensuring the safe and efficient shipment and delivery of goods and services (Ivanov, 2024) across the globe. Several scholars have stated that Information Communication Technologies (ICT) enablers improve supply chain performance (Guo, Choi, & Shen, 2020; Haq, Hameed, & Raheem, 2020; Toku & Offei, 2024) and reduce order time while reducing disruptions (Betto & Garengo, 2023). However, investigations into the competence of ICT staff and ICT's agility, reliability, and efficiency, as against economic sustainable performance, are yet to be conducted (Betto & Garengo, 2023). Agility is an organization's capacity to adjust quickly to changes in demand and return to its original position. As 'reliability ensures that a resilient ICT system is trustworthy and will perform consistently', an efficient and resilient ICT system ensures that the information obtained is fit for purpose, implying that the resilient nature of any ICT system ensures that all stakeholders' expectations are met now and, in the future, (Offei & Toku, 2023). Competent ICT staff are individuals who are physically and psychologically capable of carrying out their given activities (Lukjanova, Sushchenko, & Zyma, 2019).

This research argues that although ICT resilience enablers such as agility, reliability and efficiency improve organizational performance, the presence of robust ICT employees equipped with the necessary skills and knowledge in IT will contribute enhanced value to the firms' performance. This study is unique in its examination of ICT resilience enablers, namely competent ICT employees, agility, efficiency and reliability strategies, because they interact with one another to envisage, mitigate, sense, and respond to intentional and unintentional threats, including arson, terror attacks, adulteration, damage to goods, delivery failure, product defects, and theft, among others. Therefore, it will serve as an adaptable resource for policymakers in the import-export industry to ensure lower defects, reliable delivery, and customer satisfaction (Ali, Nagalingam, & Gurd, 2018). Accordingly, by tracking performance metrics and adjusting operations, import-export businesses can improve their ability to respond to changes and enhance their overall flexibility and competitiveness. Considering the foregoing, the objectives of this study is to determine whether ICT resilience enablers, such as agility, efficiency and reliability, are significantly related to economic sustainable supply chain performance within Ghana Ports and Harbours Authority area in Tema, Ghana; and whether the presence of competent ICT

staff mediates the relationship between ICT resilience enablers and 'economic sustainable supply chain performance'. The rest of the research paper is arranged as follows: review of literature, methods, analysis and results, managerial implications and conclusion.

2. Review of Literature

2.1. Economic Sustainable Supply Chain Performance

The seaports in Ghana are the major revenue generators for the country's development; and as a result, much more attention has to be paid to this sector in order to minimise disturbances that may affect revenue. The need to have a resilient Ports and Harbours industry to support a stable supply chain system that will bring the needed revenue to fund the economy is key. Ports and harbours can have a significant impact on a country's economic sustainability because they allow businesses to focus on solving economic issues through 'vessel handling, stevedoring, transfer, safety, security, storage, receipt, and delivery' of containerized and general cargo while also benefiting society. According to a recent meta-analysis conducted by Govindan, Rajeev, Padhi, and Pati (2020) the majority of research has focused on environmental and social firm performance and its impact on sustainability practices; however, the authors did not evaluate firms' economic success. Another study, conducted by Qorri, Gashi, and Kraslawski (2021) examined the relationship between sustainable supply chain management practices and economic, environmental, social, and operational performance; however, it did not include ICTARE as an independent variable to assess its impact on specific dimensions of firm performance. This study is therefore interested in assessing how ICT resilience enablers will influence ESSCP in the Ghanaian Ports and Harbours sector. This paper focuses on ICT agility, reliability, efficiency and competent IT staff within the Ports and Harbours firms and their relationship with the performance of an economic sustainable supply chain. Supply Chain Performance (SCP) refers to the activity of the supply chain in meeting customer needs, including the availability of the product and product delivery on time (Das & Hassan, 2022). In this research, ESSCP denotes to the Ports and Harbours businesses that import and export goods and services at the right quality and time to satisfy customers so they can, in turn, make some financial gains to sustain their businesses. It is being measured using quality of services, efficient delivery and customer satisfaction (Agyabeng-Mensah et al., 2020). According to Sundarakani, Kamran, Maheshwari, and Jain (2020) 'all the necessary inventory and capacity in the supply chain should be delivered and performed responsively'. Many Ports and Harbours authorities have engaged in the measurement of the outcome of the supply chain. These outcomes direct them in their quest to ensure their supply chains meet the necessities of its treasured and esteemed clients. ESSCP is based on the resilience that business owners employ to support the operation of their enterprises. Ports and Harbours firms operate as intermediaries between producers and carriers to ensure consumer satisfaction in a supply chain (Burgess, Singh, & Koroglu, 2006; Butt, 2021). Thus, the performance of Ports and Harbours enterprises is heavily reliant on the supply chain network and the connections between manufacturers and distributors (Li, Wang, Ye, Chen, & Zhan, 2022). Efficient and effective supply chain partnerships among supply network actors will increase performance since bad supply networks will be unable to meet customer demand and profit expectations (Asamoah, Agyei-Owusu, Andoh-Baidoo, & Ayaburi, 2021; Tarigan, Mochtar, Basana, & Siagian, 2021).

2.2. ICT Agility

ICT agility refers to an organization's capacity to respond quickly to changes in its external environment. "Agile working is about bringing people, processes, connectivity and technology, time and place together to find the most suitable and better way of working to carry out a particular task". It is also the ability of an ICT system to adapt responsively to the organization's situational needs; thus, an agile ICT system should be flexible enough to allow other modules of the system to be added seamlessly without affecting the structure of the core ICT system in place (Offei & Toku, 2023). Acar et al. (2014) defines supply chains as the agility with which production, service processes, and materials move. According to the literature, agility refers to a company's ability to respond swiftly to consumer needs in a volatile ecosystem. According to McAllister, McAllister, Richard Jr, and Baker (2022) agility is the ability to adjust to changing conditions, maintain endurance, and recover quickly from disturbances. Agility is often referred to as flexibility and sensitivity. To manage these skills, the firm must maintain effective and efficient relationships with suppliers, consumers, and stakeholders (Gandhi, Kumar, & Singh, 2017). Dynamic capabilities frequently assist firms in integrating and developing their internal and external competences to face an environment that is rapidly changing over time (Teece, Pisano, & Shuen, 1997). It is against this backdrop that this study hypothesized that:

H_{1a}: ICT agility is positively related to IT staff competence.

H_{1b}: ICT agility is positively related to ESSCP.

2.3. ICT Reliability

A reliable ICT system is dependable, timely, and truthful, and it will disseminate regardless of the circumstances. The heart of reliability is the system's capacity to function without failure. In the event of a disaster, reliability assures that a resilient ICT system is trustworthy and will work consistently (Offei & Toku, 2023). The assurance of the internet is what drives so many people to rely on it despite being aware of the risks.

Individuals, communities, companies, and governments trust and feel that the internet is safe, thus they upload both private and public content to it. Furthermore, a reliable ICT system provides the firm with the ability to handle predictable and unpredicted requests with accurate forecasting using real-time information, end-to-end visibility and transparency in the supply chain purpose (Kumar, Singh, & Modgil, 2020) which leads to an increase in firm performance. Reliable abilities thus indicate increasing firm capacities and capabilities to respond quickly and more effectively under the (un)certain environment. As companies globalize, they face demand variations, security, and reliability issues, hence the need to secure and make their supply chain reliable through ICT. This research argues that through the lens of dynamic capability, ports and harbours will be more reliable through the sensing and responding capabilities of the dynamic capability theory; hence it is proposed that;

H_{2a}: ICT reliability is positively related to IT staff competence.

H_{2b}: ICT reliability is positively related to ESSCP.

2.4. ICT Efficiency

The resilience of an ICT system is defined as the system's ability to handle seamless operations effectively by addressing the challenge at hand (Offei & Toku, 2023) implying that a resilient system enables users to make a quick transition between idea inception and operationalization by allowing them to be flexible and innovative. As a result, the design of a robust ICT system can appropriately address its intended purpose. All types of users can have simultaneous and fast access to essential information, ensuring that their results increase. A robust ICT system should include features such as completeness, simplicity of use, uniqueness, and continuity, among others. The goal of efficiency is to reduce the resources utilized in the ICT system while yet producing the same or better results. According to Kestenbaum and Straight, efficiency evaluates the unit cost of necessary output, work measurement (labor input), and project cycle time. ICT efficiency also discusses how resilience is given and completed on time to prevent destruction. This is so since the longer it takes to recover from a destruction, the higher the cost of service or product provision. The adoption of ICT efficiency in terms of fitness for purpose for a ports and harbours company will help the firm to obtain benefits namely; accurate decision-making, flexibility, solid risk management culture and enhanced resilience which increases a firm's economic supply chain management robustness abilities and performance (Dasaklis, Voutsinas, Tsoulfas, & Casino, 2022; Dutta, Choi, Somani, & Butala, 2020). It is against this setting that this study hypothesizes that:

H_{3a}: ICT efficiency is positively related to IT staff competence.

H_{3b}: ICT efficiency is positively related to ESSCP.

2.5. Competence of ICT Staff

Competence and skilled employees are the most valuable assets to any company. Their talents enable them to develop practical solutions for their firms during times of instability. These fashioned solutions produce value for the organizations for which they operate. Solutions to the world's countless issues are resolved through the abilities of employees, who put their skills at the disposal of their organizations or communities. As a result, the more competent ICT personnel are, the more robust the ICT systems and services they provide (Offei & Toku, 2023). The internet would have crumbled during the covid-19 epidemic if ICT professionals who established computer networks and ICT services (Pettersson, 2018) around the world had not been so competent. Teaching and continual training generate the necessary abilities; thus, some of these technical ICT professionals received apprenticeship training while working with skilled superiors. As a result, competent ICT workers ensure organizational success (Chokheli, 2012). Competent ICT personnel foster effective communication between internal and external supply chain associates, increasing supply chain agility, reliability, and efficiency through an information-sharing platform and better resilience capabilities (Haroon, Sami, Rehman, Fahad, & Irfan, 2019; Muheidat, Patel, Tammisetty, Tawalbeh, & Tawalbeh, 2022). Suitable personnel who are trained and given the necessary skills become a resource in turbulent situations. These sufficient knowledge in ICT and fitness, add value and enhance organizational performance (Molin, Haelermans, Cabus, & Groot, 2021). Therefore, dynamic capabilities improve sustainable performance. The study therefore hypothesizes the following;

H_{4a}: 'ICT staff competence mediates the relationship between ICT agility and ESSCP positively'.

H_{4b}: 'ICT staff competence mediates the relationship between ICT reliability and ESSCP positively.'

H_{4c}: 'ICT staff competence mediates the relationship between ICT efficiency and ESSCP positively'.

2.6. Supporting Theory

To enhance resilience performance, the dynamic capability theory posits that firms should place emphasis on configuration and alignment of internal and external resources to enhance competitive advantage (Teece et al., 1997) and enable firms to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments. The theory also posits that in an era of disruption, the resource base of the firm is reconfigured, realigned, developed, and integrated to sense changes in the business environment. Previous research has used the dynamic capabilities viewpoint to better understand the relationship between IT and corporate performance. All of this research agreed that IT primarily improves firms by enabling "unique complementarities with dynamic capability" (Liu, Ke, Wei, & Hua, 2013). Given that ICT resilience enablers are an extension of IT and resilience is closely associated with a firm's performance in a turbulent environment,

dynamic capability and its subdimensions are an ideal tool to explain the relationship between ICT resilience enablers and economic sustainable supply chain performance. Sensing and responding are the two major aspects of dynamic capability (Conboy, Mikalef, Dennehy, & Krogstie, 2020). Sensing is the ability to use available resources to recognize opportunities caused by changes in the external environment, whereas responding is the ability to act after seeing an opportunity (Ojha, Patel, & Sridharan, 2020). We contend that these two subdimensions of dynamic capability are operationalized through agility, dependability, efficiency, and the competencies of IT personnel.

To sum up, ICT agility, reliability, efficiency and robust IT staff are special capabilities of the dynamic capability theory that can highlights supplier relationships, visibility, flexibility and adoption to mitigate and respond to changes in the import-export industry (Haq et al., 2020). The integration of these unique dynamic strategies aided by IT infrastructure will provide a framework for import-export businesses to sense, mitigate, secure, and enhance reliability and ultimately achieve resilience in a turbulent environment. Based on the foregoing, we created a model from a dynamic capabilities perspective to carefully investigate the linkages between ICT agility, reliability, efficiency, strong personnel, and economic supply chain performance.

3. Methodology

3.1. Study Context

Those who were used as informants for this study are procurement and ICT officials who work as clearing agents in the Port and Harbour industry at Tema in Ghana. These officers use ICT tools and platforms to perform their routine activities in shipment of good and services. The population frame is homogenous and so purposive and convenient sampling techniques were used to administer the questionnaires. Informants were given a paper questionnaire and the responses were collected over a three months period. The response rate for this study was 83.3%. Out of the 300 questionnaires that were administered, we received 250 responses. Table 1 provides the general information of the descriptive statistics.

Figure 1 illustrate the conceptual framework of this study.

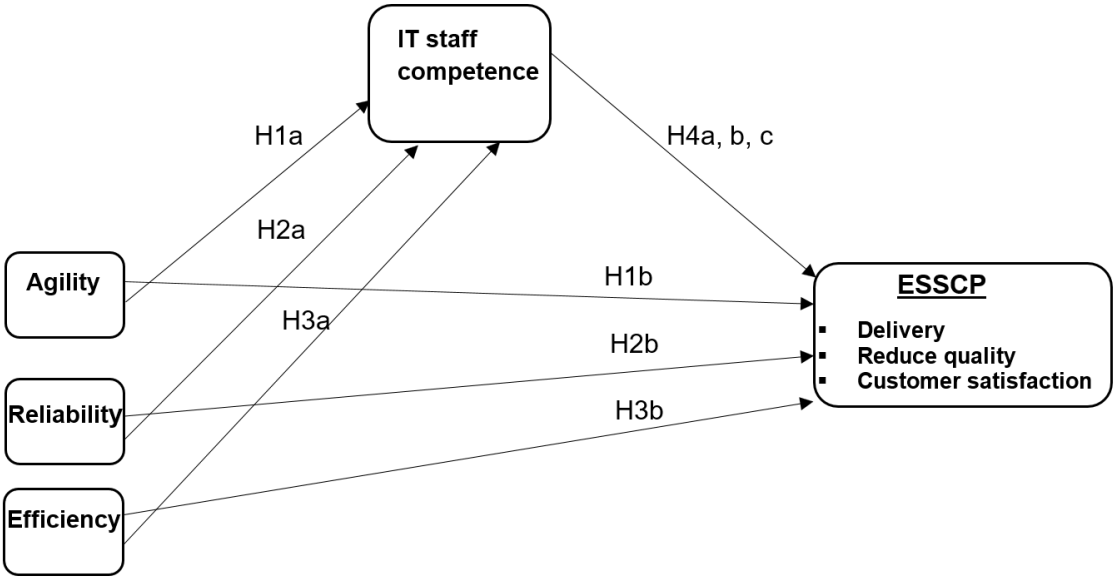

Figure 1. Research model.

3.2. Instrumentation

Constructs used in this study are reflective and second order with a '5-point Likert scale (with 1-not strongly agree to 5 strongly agree)'. The ICT resilience constructs agility, reliability and efficiency, which form the independent variables, were adopted from Offei and Toku (2023) and adapted for this study. Competence of ICT staff (ICT robustness), which constitutes the mediator, was also adapted from Offei and Toku (2023). The dependent variable, economic sustainable supply chain performance, which is measured by delivery, reduced quality and customer satisfaction, were adapted from Muhammad Auwal, Mohamed, Nasir Shamsudin, Sharifuddin, and Ali (2020) and Zailani, Jeyaraman, Vengadasan, and Premkumar (2012). These dimensions were modelled to measure different aspect of the underlying construct. We content validated these constructs using five (5) expects, two of which are scholars in the arena of 'supply chain management' at the level of Senior Lecturer, and three practitioners from the Ports and Harbours Authority who use ICT to perform their activities daily. The revision was incorporated before a pilot study of 30 respondents was carried out. All these processes helped us to validate the construct for the study to be done.

Table 1. Construct reliability and validity / AVE, HTMT, FL.

S/N	Construct	Means	Standard deviation	"AVE"	"CR"	"CA"	"1"	"2"	"3"	"4"	"5"
1	Agility (Agl)	4.5	0.041	0.723	0.927	0.951	0.811				
2	Reliability (Rel)	4.3	0.045	0.725	0.949	0.883	0.607	0.757			
3	Efficiency (Eff)	4.4	0.049	0.832	0.893	0.898	0.674	0.739	0.735		
4	ICT staff competence (Comp)	4.2	0.052	0.700	0.891	0.924	0.771	0.735	0.659	0.875	
5	Economic sustainable supply chain Mgt	4.5	0.042	0.728	0.912	0.924	0.692	0.645	0.611	0.678	0.859

Note: NB: Average variable extracted (AVE), Construct reliability (CR), Cronbach alpha (CA).

3.3. Data Collection

All the data were collected from the Tema Ports and Harbour enclave to ensure there is no uncommon biases. A total of 300 respondents were conveniently administered with the questionnaire with 250 having been returned, which represent a response rate of 83.3%. Data was collected over a three months period to ensure maximum representation of the questionnaires sent. The respondents were averagely between the ages of 30 and 35 (51%) and 36 and 40 (25%).

4. Analysis and Results

Smart PLS 3.2 was used to analyze and measure both the inner and outer model of the conceptual to confirm and validate the structural model of this study. This study, which is quantitative in nature, used the experimental approach. To avoid the common method bias, Harman single method of loading all the measurement items onto a single construct was used and it was determined that the variance was only 20%, which is far below the limit of 50% of the variance. This shows that the study's common technique bias is absent.

4.1. Assessment of Measurement Model

In order to establish the credibility of this study, the measurement of all the underlying constructs needs to pass a reliability and validity test. To determine construct reliability, Cronbach alpha, values of ≥0.7 were obtained in all the underlying constructs signifying reliability as shown in Table 2. Construct validity was established with average variance extracted (AVE), Heterotrait–monotrait (HTMT) and Fornell and Larcker (1981) criterion. These were used to establish construct discriminate validity. All threshold AVE≥0.5, HTMT≤1.0 and Fornell Larcker (FL), which ensure AVE's values are higher than the square root of inter-item correlation values, is all confirmed using Hair, Sarstedt, and Ringle (2019) standard. This can be seen in Table 2. All the study's constructs are reflective in nature and they are all first order constructs with the exception of the dependent variable (economic sustainable supply chain performance), which is second order with three dimensions.

4.2. Structural Model and Hypotheses Testing

Psychometric properties were determined by testing the estimates that established the theorical model of this study, and the path coefficients estimates and the values (β, t) that establishes the strength and direction of the relationships are shown in Table 2.

Table 2. Cross loadings.

ICT resilient enablers	Agility	Reliability	Efficiency	Staff competence	ESSC
Agility 1	0.875				
Agility 2	0.872				
Agility 3	0.877				
Agility 4	0.879				
Agility 5	0.875				
Reliability 1		0.875			
Reliability 2		0.878			
Reliability 3		0.877			
Reliability 4		0.879			
Reliability 5		0.875			
Efficiency 1			0.875		
Efficiency 2			0.972		
Efficiency 3			0.777		
Efficiency 4			0.879		
Staff competence1				0.775	
Staff competence2				0.795	
Staff competence3				0.872	
Staff competence4				0.775	
ESSC(D1)					0.875
ESSC(D2)					0.872
ESSC(CS3)					0.877
ESSC(CS4)					0.779
ESSC(QoS5)					0.879
ESSC(QoS6)					0.875

Note: NB: Agility (Agl), Reliability (Rel), Efficiency (Rel), Efficiency (Eff), Competence (Comp), Economic sustainable supply chain (ESSC- Delivery (D), Customer satisfaction (CS), Quality of service (QoS).

Our model includes direct and indirect (mediated) relationships among the independent variable (ICT resilient enablers – Agility, Reliability, Efficiency) and dependents variables (IT Staff Competence and Economic Sustainable Supply Chain Performance). We began testing our model first by dealing with direct effects. Agility positively influence ICT staff competence (H1a) (β=0.222, t=2.389) and Economic Sustainable Supply Chain Performance (H1b) (β=0.287, t= 2.655). The advent of ICT technologies dynamics capabilities in business organization is of essence because the turbulence of the business environment requires that the organization responds to expansion and contraction quickly to adapt to the rapid unexpected changes (Kanski, Budzynska, & Chadam, 2023) and agility is prominent in this direction. The reliance of organizations on ICT cannot be over emphasised since ICT resilience ensures that communication among organizations is established for goods and services to reach their respective customers in good time for them to be satisfied. Other studies have looked at digital competence and learners' agility (Patwardhan, Mallya, Shedbalkar, Srivastava, & Bolar, 2023) and this relationship is positive and significant (β= 0.33; p < 0.001). Thus COVID-19 inflicted serious disruptions in supply chain routes that required organizations to rely heavily on ICT resilience to ensure their businesses survived (Offei & Toku, 2023). Any ICT adoption that does not look at ICT resilience (Offei & Toku, 2023) is bound to fail; hence, supporting the novelty of this study. Secondly, this study posits that ICT reliability positively influences ICT competence (H2a) (β = 0.349, t = 4.252) and economic sustainable supply chain performance (H2b) (β=0.578, t= 7.918). Consistent with other studies He, Hu, Li, and Hu (2023) and Azadi et al. (2023) this study suggests that ICT reliability positively influences ICT staff competence. The theory of dynamic capabilities ensures that systems are lubricated and run seamlessly (Shiralkar, Bongale, Kumar, Kotecha, & Prakash, 2021) to improve performance. Furthermore, ICT efficiency positively influences ICT competence (3a) (β=0.354, t=4.738) and positively influences economic sustainable supply chain performance (3b) (β=0.415, t=6.173). This claim is in line with Yu, Wang, and Hu (2023) assertion that efficiency enhances 'organizational performance'. All these are shown in Table 3.

Table 3. Hypotheses paths and decisions.

Hypotheses	Paths	B	t-values	Decision
H1a	Agl>>Comp	0.222	2.389	Supported
H1b	Agl>>ESSC	0.287	2.655	Supported
H2a	Rel>>Comp	0.349	4.252	Supported
H2b	Rel>>ESSC	0.578	7.918	Supported
H3a	Eff>>Comp	0..354	4.738	Supported
H3b	Eff>>ESSC	0.415	6.173	Supported
H4a	Agl>>Comp>>ESSC	0.219	2.23	Partial mediation
H4b	Rel>>Comp>>ESSC	0.429	8.261	Full mediation
H4c	Eff>>Comp>>ESSC	0.214	2.594	Partial mediation

The variance account factor (VAF) used to determine the mediation effect of a variable in a relationship is true when 0.2 < VAF < 0.8 to represents partial mediation and VAF>0.8 to determine full mediation (Hair et al., 2019). From this study the relationship between agility and 'economic sustainable supply chain performance' is partially mediated by ICT staff competence (β=0.219, t=2.23), and is the same as the relationship between ICT efficiency and economic sustainable supply chain (β = 0.214, t = 2.594). This is supported by Yu et al. (2023) and Abbas, Hassan, and Rehman (2023) propositions as indicated in mediation (Table 4). Consequently, an efficient ICT system always guarantees higher levels of efficiency; but this efficiency will depend on how competent ICT staff handle these systems to maximize productivity (García-Alcaraz et al., 2020; Mergoni, Soncin, & Agasisti, 2023). However, the relationship between ICT reliability through ICT staff competence to economic sustainable supply chain performance is fully mediated by ICT staff competence (β=0.429, t=8.261). This supports the assessment of Shiralkar et al. (2021); Kumar et al. (2020) and García-Alcaraz et al. (2020) that reliability of ICT systems ensures supply chain paths are communicated to businesses in order to manage their expectations in anticipation of the arrival of goods and services. According to Leischnig, Wölfl, Ivens, and Hein (2017) "sensing the dimension of dynamic capability is related to ICT competence," and the results of this sensing dimension can help enterprises adapt better to the market through enhanced performance.

Table 4. Mediation.

S/N	Relationship	Direct effect	Indirect effect	Total effect	VAF	Decision
1	Agl>>ESSC	0.544	0.451	0.995	0.453	Partial
2	Rel>>ESSC	0.121	0.779	0.900	0.866	Full
3	Eff>>ESSC	0.534	0.345	0.879	0.392	Partial

5. Managerial and Staff Implication

This study show how important ICT staff competence is in the equation of economic sustainable supply chain performance within the Ports and Harbours industry. Most of the communications among the supply

chain channels are dealt with through ICT and it is importance that staff competence is enhanced to forestall any failures that may impede the smooth transition of goods and services to consumers. The ICT enablers such as agility, efficiency and reliability are crucial to the achievement and sustenance of economic sustainable supply chain performance and it is important for supply chain managers to invest in ICT systems that ensures this is achieved. Failure to develop a more resilience ICT system within the supply chain environment of the Port and Harbours sector will completely collapse businesses that rely heavily on these supply chain routes. Industry players will have to ensure they have secure ICT systems that are resilient to minimize disruptions. Collaboratory efforts among ICT systems within the industry should be pursued vigorously by pooling all ICT competences across the various stakeholders to deal with any unforeseen disruption within the industry.

6. Conclusion

A lot of development will be seen when resilient supply chain enablers are given the required attention within the environment of Ports and Harbours with regards to economic supply chain performance. With the rampant occurrence of disruptions and instabilities around the world, ICT resilient supply chain matters need to be consciously considered. Businesses involving Ports and Harbours must be safeguarded from attacks that will have a negative impact on economic supply chain performance since supply chain operations are exposed to unknown catastrophes. Contemporary businesses should have an all-inclusive strategy and a robust ICT resilient infrastructure in place that can successfully handle the manifestation of any turbulence and high-profile catastrophic and disruptive events such as arson, terror attacks, tsunamis, fire outbreaks, floods and earthquakes, which are detrimental to business operations.

References

Abbas, M., Hassan, K. H. U., & Rehman, R. U. (2023). Exploring the role of ICT in developing teachers' ICTs competencies through promotion-linked-training bs 17 to bs 18 QAED during PLT at the Punjab level. *Journal of Social Sciences Review*, *3*(1), 747-757. https://doi.org/10.54183/jssr.v3i1.209

Acar, G., Eubank, C., Englehardt, S., Juarez, M., Narayanan, A., & Diaz, C. (2014). *The web never forgets: Persistent tracking mechanisms in the wild*. Paper presented at the Proceedings of the 2014 ACM SIGSAC Conference on Computer and Communications Security.

Agyabeng-Mensah, Y., Ahenkorah, E., Afum, E., Nana Agyemang, A., Agnikpe, C., & Rogers, F. (2020). Examining the influence of internal green supply chain practices, green human resource management and supply chain environmental cooperation on firm performance. *Supply Chain Management: An International Journal*, *25*(5), 585-599. https://doi.org/10.1108/scm-11-2019-0405

Ali, I., Nagalingam, S., & Gurd, B. (2018). A resilience model for cold chain logistics of perishable products. *The International Journal of Logistics Management*, *29*(3), 922-941. https://doi.org/10.1108/ijlm-06-2017-0147

Asamoah, D., Agyei-Owusu, B., Andoh-Baidoo, F. K., & Ayaburi, E. (2021). Inter-organizational systems use and supply chain performance: Mediating role of supply chain management capabilities. *International Journal of Information Management*, *58*, 102195. https://doi.org/10.1016/j.ijinfomgt.2020.102195

Azadi, M., Moghaddas, Z., Saen, R. F., Gunasekaran, A., Mangla, S. K., & Ishizaka, A. (2023). Using network data envelopment analysis to assess the sustainability and resilience of healthcare supply chains in response to the COVID-19 pandemic. *Annals of Operations Research*, *328*(1), 107-150. https://doi.org/10.1007/s10479-022-05020-8

Betto, F., & Garengo, P. (2023). A circular pathway for developing resilience in healthcare during pandemics. *International Journal of Production Economics*, *266*, 109036. https://doi.org/10.1016/j.ijpe.2023.109036

Burgess, K., Singh, P. J., & Koroglu, R. (2006). Supply chain management: a structured literature review and implications for future research. *International Journal of Operations & Production Management*, *26*(7), 703-729.

Butt, A. S. (2021). Strategies to mitigate the impact of COVID-19 on supply chain disruptions: a multiple case analysis of buyers and distributors. *The International Journal of Logistics Management*. https://doi.org/10.1108/ijlm-11-2020-0455

Chakma, U., Li, B., & Kabuhung, G. (2021). Creating online metacognitive spaces: Graduate research writing during the COVID-19 pandemic. *Issues in Educational Research*, *31*(1), 37-55.

Chokheli, E. (2012). The perfecting tasks of management of organizational changes in business companies. *Economics*, (7), 8.

Conboy, K., Mikalef, P., Dennehy, D., & Krogstie, J. (2020). Using business analytics to enhance dynamic capabilities in operations research: A case analysis and research agenda. *European Journal of Operational Research*, *281*(3), 656-672. https://doi.org/10.1016/j.ejor.2019.06.051

Das, S., & Hassan, H. K. (2022). Impact of sustainable supply chain management and customer relationship management on organizational performance. *International Journal of Productivity and Performance Management*, *71*(6), 2140-2160. https://doi.org/10.1108/ijppm-08-2020-0441

Dasaklis, T. K., Voutsinas, T. G., Tsoulfas, G. T., & Casino, F. (2022). A systematic literature review of blockchain-enabled supply chain traceability implementations. *Sustainability*, *14*(4), 2439. https://doi.org/10.3390/su14042439

Dutta, P., Choi, T.-M., Somani, S., & Butala, R. (2020). Blockchain technology in supply chain operations: Applications, challenges and research opportunities. *Transportation Research Part e: Logistics and Transportation Review*, *142*, 102067. https://doi.org/10.1016/j.tre.2020.102067

Essuman, D., Boso, N., & Annan, J. (2020). Operational resilience, disruption, and efficiency: Conceptual and empirical analyses. *International Journal of Production Economics*, *229*, 107762. https://doi.org/10.1016/j.ijpe.2020.107762

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, *18*(1), 39-50. https://doi.org/10.1177/002224378101800104

Gandhi, S., Kumar, S., & Singh, R. (2017). Supply chain flexibility, agility and firm performance. *European Journal of Logistics, Purchasing and Supply Chain Management*, *5*(3), 13–40.

García-Alcaraz, J. L., Martínez-Loya, V., Díaz-Reza, J. R., Blanco-Fernández, J., Jiménez-Macías, E., & Lopez, A. J. G. (2020). Effect of ICT integration on SC flexibility, agility and company'performance: the Mexican maquiladora experience. *Wireless Networks*, *26*(7), 4805-4818. https://doi.org/10.1007/s11276-019-02068-6

Govindan, K., Rajeev, A., Padhi, S. S., & Pati, R. K. (2020). Supply chain sustainability and performance of firms: A meta-analysis of the literature. *Transportation Research Part E: Logistics and Transportation Review*, *137*, 101923. https://doi.org/10.1016/j.tre.2020.101923

Guo, S., Choi, T.-M., & Shen, B. (2020). Green product development under competition: A study of the fashion apparel industry. *European Journal of Operational Research*, *280*(2), 523-538. https://doi.org/10.1016/j.ejor.2019.07.050

Hair, J. F., Sarstedt, M., & Ringle, C. M. (2019). Rethinking some of the rethinking of partial least squares. *European Journal of Marketing*, *53*(4), 566-584. https://doi.org/10.1108/ejm-10-2018-0665

Haq, M. A., Hameed, I., & Raheem, A. (2020). An empirical analysis of behavioral flexibility, relationship integration and strategic flexibility in supply chain agility: Insights from SMEs sector of Pakistan. *South Asian Journal of Management Sciences*, *14*(1), 104-121. https://doi.org/10.21621/sajms.2020141.06

Haroon, A., Sami, A., Rehman, S., Fahad, H., & Irfan, A. (2019). Sustainable leadership enhance innovation: A systematic review of past decade. *Journal of Public Value and Administrative Insight*, *2*(4), 1-5.

He, X., Hu, W., Li, W., & Hu, R. (2023). Digital transformation, technological innovation, and operational resilience of port firms in case of supply chain disruption. *Marine Pollution Bulletin*, *190*, 114811. https://doi.org/10.1016/j.marpolbul.2023.114811

Ivanov, D. (2024). Two views of supply chain resilience. *International Journal of Production Research*, *62*(11), 4031-4045. https://doi.org/10.1080/00207543.2023.2253328

Kanski, L., Budzynska, K., & Chadam, J. (2023). The impact of identified agility components on project success—ICT industry perspective. *PLoS One*, *18*(3), e0281936. https://doi.org/10.1371/journal.pone.0281936

Kumar, A., Singh, R. K., & Modgil, S. (2020). Exploring the relationship between ICT, SCM practices and organizational performance in agri-food supply chain. *Benchmarking: An International Journal*, *27*(3), 1003-1041. https://doi.org/10.1108/bij-11-2019-0500

Leischnig, A., Wölfl, S., Ivens, B., & Hein, D. (2017). From digital business strategy to market performance: Insights into key concepts and processes.

Li, L., Wang, Z., Ye, F., Chen, L., & Zhan, Y. (2022). Digital technology deployment and firm resilience: Evidence from the COVID-19 pandemic. *Industrial Marketing Management*, *105*, 190-199. https://doi.org/10.1016/j.indmarman.2022.06.002

Liu, H., Ke, W., Wei, K. K., & Hua, Z. (2013). The impact of IT capabilities on firm performance: The mediating roles of absorptive capacity and supply chain agility. *Decision Support Systems*, *54*(3), 1452-1462. https://doi.org/10.1016/j.dss.2012.12.016

Lukjanova, J., Sushchenko, O., & Zyma, O. (2019). *Educated and competent staff as important factor of innovation development of machine-building and metalworking industry in Latvia*. Paper presented at the MATEC Web of Conferences.

McAllister, T. P., McAllister, T. P., Richard Jr, F., & Baker, A. (2022). *Assessment of resilience in codes, standards, regulations, and best practices for buildings and infrastructure systems*: US Department of Commerce, National Institute of Standards and Technology.

Mergoni, A., Soncin, M., & Agasisti, T. (2023). The effect of ICT on schools' efficiency: Empirical evidence on 23 European countries. *Omega*, *119*, 102891. https://doi.org/10.1016/j.omega.2023.102891

Molin, F., Haelermans, C., Cabus, S., & Groot, W. (2021). Do feedback strategies improve students' learning gain?-Results of a randomized experiment using polling technology in physics classrooms. *Computers & Education*, *175*, 104339. https://doi.org/10.1016/j.compedu.2021.104339

Muhammad Auwal, A., Mohamed, Z., Nasir Shamsudin, M., Sharifuddin, J., & Ali, F. (2020). External pressure influence on entrepreneurship performance of SMEs: a case study of Malaysian herbal industry. *Journal of Small Business & Entrepreneurship*, *32*(2), 149-171. https://doi.org/10.1080/08276331.2018.1509504

Muheidat, F., Patel, D., Tammisetty, S., Tawalbeh, L. a. A., & Tawalbeh, M. (2022). Emerging concepts using blockchain and big data. *Procedia Computer Science*, *198*, 15-22. https://doi.org/10.1016/j.procs.2021.12.206

O'Leary, D. E. (2020). Evolving information systems and technology research issues for COVID-19 and other pandemics. *Journal of Organizational Computing and Electronic Commerce*, *30*(1), 1-8. https://doi.org/10.1080/10919392.2020.1755790

Offei, M. O., & Toku, L. (2023). ICT resilient framework for smart supply chains in global epidemics. *Journal of Management*, *10*, 13-19.

Ojha, D., Patel, P. C., & Sridharan, S. V. (2020). Dynamic strategic planning and firm competitive performance: A conceptualization and an empirical test. *International Journal of Production Economics*, *222*, 107509.

Patwardhan, V., Mallya, J., Shedbalkar, R., Srivastava, S., & Bolar, K. (2023). Students' digital competence and perceived learning: the mediating role of learner agility. *F1000Research*, *11*, 1038.

Pettersson, F. (2018). On the issues of digital competence in educational contexts–a review of literature. *Education and Information Technologies*, *23*(3), 1005-1021. https://doi.org/10.1007/s10639-017-9649-3

Qadri, U. A., Ghani, M. B. a., Bibi, S., Tahir, A. H., Farooq, M. I., & Kashif, A. R. (2024). The learning effect on organizational performance during a crisis: A serial mediation analysis with knowledge creation, storage and sharing. *European Journal of Management and Business Economics*, *33*(1), 37-53.

Qorri, A., Gashi, S., & Kraslawski, A. (2021). Performance outcomes of supply chain practices for sustainable development: A meta-analysis of moderators. *Sustainable Development*, *29*(1), 194–216.

Rodríguez-Espíndola, O., Chowdhury, S., Dey, P. K., Albores, P., & Emrouznejad, A. (2022). Analysis of the adoption of emergent technologies for risk management in the era of digital manufacturing. *Technological Forecasting and Social Change*, *178*, 121562.

Shiralkar, K., Bongale, A., Kumar, S., Kotecha, K., & Prakash, C. (2021). Assessment of the benefits of information and communication technologies (ICT) adoption on downstream supply chain performance of the retail industry. *Logistics*, *5*(4), 80.

Sundarakani, B., Kamran, R., Maheshwari, P., & Jain, V. (2020). Designing a hybrid cloud for a supply chain network of industry 4.0: A theoretical framework. *Benchmarking: An International Journal*, *27*(6), 1743–1766.

Tarigan, Z., Mochtar, J., Basana, S., & Siagian, H. (2021). The effect of competency management on organizational performance through supply chain integration and quality. *Uncertain Supply Chain Management*, *9*(2), 283-294.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, *18*(7), 509-533.

Toku, L., & Offei, M. O. (2024). The influence of artificial intelligent, internet of things and cyber security on supply chain management performance. In *Green Industrial Applications of Artificial Intelligence and Internet of Things* (pp. 144-159): Bentham Science Publishers.

Tukamuhabwa, B., Stevenson, M., & Busby, J. (2017). Supply chain resilience in a developing country context: a case study on the interconnectedness of threats, strategies and outcomes. *Supply Chain Management: An International Journal*, *22*(6), 486-505. https://doi.org/10.1108/scm-02-2017-0059

Wang, Y., & Yang, J. (2021). Role of supplier involvement and project leader in SNPD: a conceptual model and exploratory case study. *International Journal of Managing Projects in Business*, *14*(4), 960-981. https://doi.org/10.1108/ijmpb-07-2020-0206

Yu, R., Wang, M., & Hu, J. (2023). The relationship between ICT perceived competence and adolescents' digital reading performance: A multilevel mediation study. *Journal of Educational Computing Research*, *61*(4), 817-846. https://doi.org/10.1177/07356331221137107

Zailani, S., Jeyaraman, K., Vengadasan, G., & Premkumar, R. (2012). Sustainable supply chain management (SSCM) in Malaysia: A survey. *International Journal of Production Economics*, *140*(1), 330-340. https://doi.org/10.1016/j.ijpe.2012.02.008