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Small and medium enterprises' adoption of 4IR technologies for supply chain resilience during the COVID-19 pandemic

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Background: This study is motivated by the scarcity of empirical literature from developing countries on the small and medium enterprises' (SMEs) adoption of Fourth Industrial Revolution (4IR) technologies and supply chain resilience (SCR) nexus during the coronavirus disease 2019 (COVID-19) pandemic.

Objectives: The study assessed the current level of 4IR adoption amongst Zimbabwean SMEs, investigated the drivers thereof and analysed the effect of 4IR technologies on SMEs' SCR amidst the COVID-19-induced disruptions.

Method: The study employed a quantitative research approach where data were collected through an online cross-sectional survey of 318 SME owners or managers in Zimbabwe. The logit regression model using the IBM SPSS software was utilised for the main estimation.

Results: The study revealed that the adoption of 4IR technology amongst Zimbabwean SMEs is still low owing to high costs and ignorance of some SME owners or managers. However, personal innovativeness, education, information and communication technology (ICT) literacy, security and ICT ease of use were the main drivers for the adoption of 4IR technology. A positive link was established between 4IR adoption and SCR.

Conclusion: This study contributes to the nascent literature on fostering SME SCR through the adoption of 4IR technologies by SMEs from developing countries, in particular. The study recommends collective efforts by all relevant stakeholders to raise awareness about 4IR technology and enhance ICT literacy whilst addressing 4IR-enabling infrastructure and internet access costs.

Keywords: SMEs; COVID-19 pandemic; 4IR adoption; Supply chain resilience; Developing countries.

Introduction

The socio-economic role of small and medium enterprises (SMEs) through employment creation, poverty alleviation and gross domestic product growth across economies is well established (Mishal, Rimsha & Chaudhry 2019:3). Studies indicate that SMEs are especially vulnerable during severe crises. Often their growth is hampered, and their resilience to supply chain disruptions weakened (Dhochak & Sharma 2015; Mason & Harrison 2015; Saturwa, Suharno & Ahmad 2021). The coronavirus disease 2019 (COVID-19) pandemic that began to spread at the beginning of 2020 revealed the vulnerability of many businesses to supply chain disruptions (Mavilia & Pisani 2021; Nasution et al. 2020; United Nations Industrial Development Organisation [UNIDO] 2020). The lockdown measures instituted in many countries disrupted production flows and regional and global supply chains, reduced demand for non-essential goods and services and forced enterprises to suspend or scale down operations (Ratten 2020; International Monetary Fund [IMF] 2020; The International Labour Organisation [ILO] 2020a). Small and medium enterprises, in particular, encountered intense business interruption risks, such as delayed or failed deliveries, acute shortage of inputs, and consequently, reduced production capacity and/or shutdowns (WTO 2020; Gurría 2020; Segal & Gerstel 2020; Thaha 2020) after WTO 2020. Hence, there is a need for SMEs to build their supply chain resilience (SCR) to cope with the volatility resulting from the COVID-19 pandemic.

The health protocols put in place to contain the pandemic, which reduced the demand for non-essential goods and services, have led to declines in SMEs' sales and cash flows (Bouey 2020;

Note: Special Collection: Impact of COVID-19 on the transport and logistics management.

Lu et al. 2020; Saturwa et al. 2021; Soetjipto 2020; Tairas 2020). Worse still, the financial fragility has pushed SMEs to lay off employees, resulting in increased unemployment (Pakpahan 2020). Whilst all SMEs across the globe have borne the brunt of the COVID-19 pandemic effects, SMEs from developing economies were worst affected as they had already faced numerous structural challenges, such as access to working capital funding, before the outbreak of COVID-19. Structural challenges in developing countries include that many of them are landlocked with severe economic and regulatory challenges, as well as the high cost of carrying out business (ITC 2020). It is evident that COVID-19 exacerbated the challenges of SMEs' operations, further compromising their SCR and flexibility in the face of unexpected economic shocks (Ali & Karimah 2020).

The extant literature shows the importance of resilient supply chains in improving SME performance, productivity, innovation, risk management, sustainability and investment decision-making in a crisis (Hejazi 2021; Chowdhury & Quaddus 2015; 2017; Abeysekura et al. 2019; McKinsey 2020; Ambulkar et al. 2015; Güner & Gündoğan 2017; Organisation for Economic Co-operation and Development [OECD] 2020c; Somabutr, Pandian & Roh, 2021). Supply chain resilience is:

> [*T*]he ability to proactively plan and design the supply chain network for anticipating unexpected disruptive (negative) events; respond adaptively to such disruptions while maintaining control over operations, and potentially gaining competitive advantage. (Ponis & Koronis 2012:925)

Some studies also suggest that during the COVID-19 pandemic, SMEs can build SCR through the adoption of the Fourth Industrial Revolution (4IR) technology, such as artificial intelligence (AI), the internet of things (IoTs), machine learning, e-commerce platforms and robotics (BDO 2020; Indriastuti & Fuad 2020; Papadopoulos, Baltas & Balta 2020). In fact, Sivaraks (2020:9) observed that the outbreak of COVID-19 pandemic has accelerated the adoption of the 4IR technology. Menon and Fink (2019) submitted that if well-adopted, 4IR has the potential to empower SMEs and facilitate effective interaction with customers and markets.

Adegbite and Govender (2021) stress that resilient SMEs are especially needed on the African continent as they adopt 4IR during the COVID-19 pandemic. Gumbi and Twinomurinzi (2020) argue that there is an overwhelming need for investigating the future of SMEs, therein leveraging 4IR technology. Thukral (2021) concurs that during the COVID-19 pandemic, SMEs should begin building their SCR as the pandemic has revealed what real disruption can be, and it has exposed the existing gaps in SMEs' operations and information and communication technology (ICT) investments. Studies suggest that the use of digital innovations helps SMEs to withstand and effectively manage the unfavourable impact of COVID-19 (Guo et al. 2020; Indriastuti & Fuad 2020; Papadopoulos et al. 2020). These observations highlight the critical role of information technology in assisting SMEs to handle difficulties resulting from the COVID-19-induced disruptions. Hence, Thukral (2021) opines that SMEs must increasingly consider incorporating 4IR technologies in their supply chains.

Studies on technology adoption have yielded a mixed bag of results. For example, Nugroho et al.'s (2017) study found that the size of a business entity influences its technology adoption decision, in that the more a business expands, the more likely it will adopt information technology with a view of improving communication with clients, whilst in a more recent study, Amornkitvikai and Lee (2020) found no association between firm size and technology adoption. Chang and Dasgupta (2015) concluded that older firms might employ workers with the right level of information technology skills required for the job. In Zimbabwe, SME studies which focused on the COVID-19 pandemic investigated the impact of COVID-19 on SME operations (Chaora 2020; Mazikana 2020; United Nations Zimbabwe 2020). It is evident that more studies are required to enhance our understanding of technology adoption of SMEs in particular. This study seeks to go a step further by exploring the SMEs' adoption of 4IR technologies for SCR during the COVID-19 pandemic. This article is organised as follows: firstly, the study reviews the literature on the COVID-19 pandemic, SCR and 4IR technology adoption. Secondly, the research methodology deployed in the study is explained. Thirdly, the study results are presented, conclusions are drawn and directions for future research suggested.

Literature review

Small and medium enterprises and the COVID-19 pandemic

Compared with large companies, SMEs are particularly vulnerable to the economic impacts of the pandemic predominantly because of their limited resources; they tend to have fewer assets, smaller cash reserves and lower levels of productivity (Saturwa et al. 2020). Moreover, as SMEs are diverse, the severity of the pandemic's impact on them varies considerably depending on the economic sectors that they trade in (Sonobe et al. 2021). The SMEs that have been hardest hit by the COVID-19 are predominantly from retail, hospitality, food, entertainment and construction services (Albaz et al. 2020; Sonobe et al. 2021). Consequently, such SMEs have had less resilience and flexibility in dealing with the costs associated with economic shocks, making it more difficult for them to survive the COVID-19 pandemic and beyond compared with larger firms (UNCTAD 2020a; WTO 2020).

Cruz et al. (2020) reported that the COVID-19-induced shocks have adversely affected SMEs globally in terms of demand, supply and uncertainty. Demand has weakened across most industries because of weak consumer sentiment and job losses, as consumers defer their non-discretionary purchases and focus on buying essential items (Bouey 2020; Ernst & Young 2020). COVID-19 has reduced consumer spending on

services like travel, entertainment, restaurants and demand from other firms, leading to a decline in exports because of disruptions in critical supply chains. In terms of supply-side shock, Cruz et al. (2020) found that COVID-19 has led to a decline in the availability of labour as businesses have reduced productivity or are under temporary closures, and employees' lives are disrupted because of COVID-19 infections and/or travel restrictions. There has also been a decline in employee productivity as workers are less efficient in adapting to new working hours and modalities of work; there are reduced business trading hours. Consequently, businesses have suffered from capacity under-utilisation, and there are no clear indications as to when normalcy will return because of the ongoing uncertainty about finding a cure for the pandemic. Ernst and Young (2020) report that the limit on the movement of people and non-essential goods has disrupted critical supply chains, leading to a shortage of raw materials.

Fourth Industrial Revolution technology adoption and supply chain resilience

According to the World Economic Forum (WEF 2017:3), 'the fourth industrial revolution is characterised by the convergence of breakthrough technologies – such as advanced robotics, AI, the IoT, virtual and augmented reality, wearables and additive manufacturing'. Hence, 4IR speaks to the essence of unexplored business opportunities through creative disruption (Munters & Marx 2017; Müller & Voigt 2018; WIPO Magazine 2019; Xu et al. 2018). A firm's adoption of 4IR technology can facilitate effective implementation of cyber-physical integration into its supply chain (Lee 2020; Alqam & Saqib 2020; Lee 2021; Ivanov & Dolgui 2021). Through the use of 4IR technologies, enterprises across the globe can transition seamlessly from the traditional, static, linear supply chain designs towards smart, connected, intelligent, scalable, customisable and nimble supply networks, which, in turn, allow uninterrupted movement of products, services, information, and big data analytics for decision-making. Africa's Pulse (2021) and BDO (2020) explains that enterprises can leverage cloud-based global positioning system (GPS) and Bluetooth Low Energy (BLE) asset tracking technologies for improving a business understanding of variable customer demand, visibility, responsiveness and resiliency throughout the supply chain.

It is observed, however, that in most developing countries, purchase, installation and subsequent running costs deter SMEs from readily adopting technology as nearly all ICT equipment is imported, let alone the relatively high rates of taxation, regulatory license fees and non-tariff barriers, exorbitant internet connectivity and telecommunications usage charges (Abualrob & Kang 2016; Saif-Ur-Rehman & Alam 2016; Mwai 2016). Rahayu & Day (2015), Walker et al. (2016) and Nugroho et al. (2017) find that whilst the progressive SME managers or owners are more inclined towards adopting technology with a view to spur on the business, technology adoption is less likely where SMEs find the IT infrastructure quite complex to optimise or merely use. Supply chain resilience is broadly concerned with the ability of supply chain to deal with instantaneous disruptive events (Soni et al. 2014; Yang & Xu 2015; Jain et al. 2017). Recently, business enterprises have become increasingly interested in enhancing their SCR (Kwak et al. 2018; Lima et al. 2018). The extant literature highlights the importance of SCR within a business enterprise. For instance, Alfarsi, Lemke and Yang (2019:3) posit that SCR enables businesses to 'sustain and attain good financial performance, improve service quality and organizational reputation, which in turn, enhance overall business attractiveness'.

According to OECD (2020), SCR equips organisations to be proactive and to quickly adapt their operations for transparency and business continuity in times of crises. Given the current uncertainty, complexity and vulnerability brought about by disruptions, a resilient supply chain ensures continuity of business operations and is a source of dynamic capability and competitive advantage (Alfarsi et al. 2019; Sadghiani, Torabi & Sahebjamnia 2015). Furthermore, yields of a 4IR-enabled resilient supply chain increased visibility and collaboration amongst all involved stakeholders (Ivanov & Dolgui 2021; Matt et al., 2016). Patsavellas, Kaur and Salonitis (2021:3), in turn, noted that such 'supply chain collaboration leads to improved decision-making particularly in situations of contingency and production efficiency, has reduced bullwhip, overall inventory and administrative costs for the whole supply chain'. Their study further establishes that over time, retailers can maintain operations without interruptions and improve customer experience, whilst upstream suppliers can build loyalty and reduce costs through information-sharing across the supply chain network. Hence, leveraging 4IR technologies, SMEs can have a real-time sight of every process and part of the supply chain and quickly and proactively identify and rectify areas of potential risk before the occurrence or swiftly respond to disruptions. Therefore, based on the above discussion, the current study proposes the following hypotheses:

H_0: SME 4IR adoption has no effect on SCR

H_1: SME 4IR adoption has an effect on SCR.

Methodology

The data

This exploratory study adopted a quantitative approach. Primary data were collected by a cross-sectional survey using an online questionnaire between 05 and 20 November 2021 using Google Forms. Respondents for the survey were selected through purposive sampling, a type of non-probability sampling method in which 'particular respondents are deliberately selected in order to provide important information that cannot be obtained from other choices' (Taherdoost 2016:7). These targeted respondents were either owners or managers across the 10 provinces in Zimbabwe whose business conformed to the Small and Medium Enterprise Development Corporation (SMEDCO 2010:3) definition of SMEs in Zimbabwe: 'a business employing no more than 100 employees and generating a maximum annual revenue of USD830 000'. The use of online

questionnaires proved cost-effective, allowed for ease of data collection, storage and visualisation and convenient, speedy and accurate feedback, including a wider reach (Bryman & Bell 2014; Nayak & Narayan 2019), allowing for compliance with the COVID-19 physical and social distancing health protocols.

The items used to operationalise the individual constructs were adapted from the literature (APEC 2021; Adam & Alarifi 2021; Hendijani & Saei 2020; Kamalahmadi & Parast 2016b; Thukral 2021; Christopher & Peck, 2004; FinScope, 2012). In addition to the binary (yes or no) option, a five-point Likert scale was used for the majority of the questions in sections 2-5, with responses ranging from 1 = 'Strongly Disagree', 4 = 'Agree' to 5 = 'Strongly Agree'. Section 1 of the questionnaire focused on the respondents' profile and the enterprise characteristics; Section 2 sought information on the COVID-19 pandemic and SME supply chains; Section 3 elicited response on SME 4IR adoption, whilst Section 4 dealt with SME SCR.

In order to enhance the validity of the survey items, the questionnaire was pre-tested on a few supply chain experts with areas of ambiguity addressed immediately. Afterwards, the corrected questionnaire was pilot-tested on 35 randomly selected respondents who complied with the study's inclusion criteria before final use in the online survey. All the ethical requirements were adhered to. Informed consent was sought from all the potential respondents, and to encourage candidness, we provided assurance and reassurance of confidentiality of their responses. Purposive sampling led to a total of 318 participants responding to the online questionnaire. The responses were checked for completeness, plausibility and integrity before data analysis, with 249 questionnaires (78%) found usable for analysis.

Study variables

The dependent variable in the regression analysis was SME 4IR adoption, whilst the independent variables (regressors) were derived from the reviewed literature. Components of SME SCR were measured using a five-point Likert scale, with responses ranging from 1 = 'Strongly Disagree', 4 = 'Agree' to 5 = 'Strongly Agree'.

Estimation model

The study employed logistics regression analysis, also known as the logit model and based on the cumulative distribution function, to analyse the determinants of 4IR technology adoption amongst Zimbabwean SMEs. Logistic regression analysis is used to determine the odds ratio in the presence of more than one explanatory variable and models the chance of an outcome based on individual characteristics (Sperandei 2014; O'Connell 2006; Fox 2015). The estimation method was selected because of its compatibility with the online survey data. Furthermore, the logistic model is favoured in adoption studies over linear regression, as it has well-organised and asymptotically reliable parameter estimates that are simple to compute (Ume et al. 2020), offers flexibility and the independent variables do not need to follow a normal distribution (Greene 2012).

As the adoption of 4IR technology (dependent variable) is dichotomous, the study sought to determine the likelihood of an SME owner or manager choosing to adopt 4IR technology. Accordingly, the dependent variable was coded 0 and 1. The SME owners or managers who adopted 4IR technologies were assigned a value of 1, whilst 0 was for the non-adopters. Consistent with Wondale, Molla and Tilahun (2016), Gujarati (1995) and Maddala (1992), the SME owner and manager distribution function for SME owner and manager 4IR technology adoption is as follows:

$$P_i = \frac{1}{1+e^{-zi}} = \frac{e^{zi}}{1+e^{zi}}, \quad \text{[Eqn 1]}$$

where

P_i is the odd technology adoption by SME owner or manager i ranging between 0 and 1, whilst 1– P_i is the likelihood of non-adoption. The observed response of the ith SME owner or manager is binary, with $P_i = 1$ for a 4IR technology adopter and $P_i = 0$ for a non-adopter,

e^{-zi} represents irrational numbers e to the power of z_i Whilst z_i is a function of the exploratory variables (regressors).

Following the lead of Ume et al. (2020), Equation (1) represents the ratio in favour of SME owner or manager's 4IR technology adoption to the odds of non-adoption. Taking the natural log of both sides of Equation (1), it follows that:

$$z = \text{In}\left(\frac{P_i}{1-P_i}\right). \quad \text{[Eqn 2]}$$

Therefore, the above function can also be shown as follows:

$$\text{In}\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_i X_i + \mu, \quad \text{[Eqn 3]}$$

where

X_i indicates the determinants of 4IR technology adoption by an SME owner or manager, β_i is the vector of parameter to be predicted using the maximum likelihood method and μ represents error term which is usually normally distributed with zero mean variance.

Data analysis and results

Table 1 reports the descriptive statistics of the study.

As shown in Table 1, 60% (150) of them were male respondents, with the highest proportion (31%) of SME owners or managers from the 41–45 years category, whilst 87 respondents (35%) had completed secondary education. About 33.33% (83) of the SMEs had been operational for

TABLE 1: Descriptive statistics.

Variable	Frequency	%
Gender		
Male	150	60
Female	99	40
Age (years)		
18–25	6	2.40
26–30	23	9.24
31–35	61	24.50
36–40	42	16.90
41–45	77	31.00
46–50	38	15.30
51+	2	0.01
Education		
None	0	0.00
Primary	12	4.82
Secondary	87	35.00
Tertiary: Technical College	49	19.68
Tertiary: Undergraduate	76	30.52
Tertiary: Postgraduate	25	10.04
SME age (years)		
< 1	11	4.42
3–5	68	27.30
6–10	83	33.33
11–15	32	12.85
16+	55	22.08
Employees		
0 to < 10	102	41.00
10 to < 25	147	59.00
25 to < 50	0	0.00
50 to < 100	0	0.00
Revenue last 12 months (USD)		
0 to < 10 000	124	49.80
10 000 to < 20 000	35	14.06
20 000 to < 50 000	72	28.92
50 000 to < 100 000	18	7.23
100 000 to 830 000	0.00	0.00
SME's business sector		
Transport	9	3.61
Agriculture	36	14.46
Information and communication	15	6.02
Professional	10	4.02
Wholesale and retail trade	48	19.28
Construction	22	8.84
Hospitality	41	16.47
Manufacturing	37	14.86
Mining	31	12.45

SME, small and medium enterprises.

TABLE 2a: Small and medium enterprise supply chain and Fourth Industrial Revolution technology adoption.

Variable	Frequency	%
International business activity		
Exporting goods and/or services to overseas	67	26.91
Importing goods and/or services from overseas	145	58.23
Neither export nor import goods and/or services	37	14.86
How many large businesses do you sell to?		
None	26	10.44
< 3	80	32.53
3–5	125	50.20
6–10	14	5.62
11+	4	1.61
Number of SMEs you sell to?		
None	49	19.68
< 3	21	8.43
3–5	68	27.31
6–10	36	14.46
11+	75	30.12
Business position in the global supply chain?		
Provide primary goods and/or services into global supply chains to then reach end consumers	40	16.06
Add value to existing goods and/or services to then reach end consumers	15	6.02
3–5	61	24.50
6–10	12	4.82
11+	7	2.81

SME, small and medium enterprise; SCR, supply chain resilience.

TABLE 2b: Small and medium enterprise supply chain and Fourth Industrial Revolution technology adoption.

4IR technology adoption	YES		NO	
	Count	%	Count	%
4IR technology adopters	107	43	142	57

4IR, Fourth Industrial Revolution.

TABLE 2c: Small and medium enterprise supply chain and Fourth Industrial Revolution technology adoption.

4IR and SME resilience	Count	%
4IR adoption builds SCR during the COVID-19 pandemic?		
Strongly disagree	0	0.00
Disagree	0	0.00
Not sure	49	46.00
Agree	39	36.00
Strongly agree	19	18.00

SME, small and medium enterprise; SCR, supply chain resilience; 4IR, Fourth Industrial Revolution.

6–10 years, 59% (147) had 10-25 employees, 49% (124) generated an income of less than $10 000, whilst only 7.23% (18) earned $50 000 up to less than $100 000. Furthermore, the descriptive statistics revealed that the dominant SME business sectors include wholesale and retail (19.28%), hospitality (16.47%), manufacturing, mainly furniture (14.86%), agriculture (14.46%) and mining (12.45%).

The results displayed in Table 2 reveal that 26.91% (67) of the SMEs exported goods and/or services overseas, whereas 58.23% (145) imported the same. As implied, the Zimbabwean SMEs were heavily dependent on input importation, which, in turn, made them vulnerable to COVID-19-induced supply chain disruptions. Furthermore, Table 2 indicates that in terms of the business position in the global supply chain, 40 (16.06%) of the SMEs provided primary goods or services into global supply chains to then reach end consumers, whilst 15 (6.02%) were involved in value addition to existing goods or services to then reach end consumers. These business entities were from the agricultural and mining sectors. The majority of SMEs (143) conducted sold goods and/or services to less than three large businesses, whilst only 2.81% (7) undertook the same with 11 or more large enterprises. On the other hand, 119 (47.79%) of the SMEs sold to between 3 and 5 other SMEs, in contrast to 35 (14.06%), which sold goods and/or services to more than 11 other SMEs.

A total of 88% of the respondents cited encountering various operational challenges before the COVID-19 pandemic (financing, language barriers, culture and business practices); 90% had encountered difficulties during the COVID-19 pandemic (reduced customer demand, delivery delays or failures, cash flow issues, increased logistics costs, reduced regional and international supplies, facility closures, air freight incapacitation and communication delays and failures). The adoption of Fourth Industrial Revolution technology is still in its embryonic stage, with 43% (107) of the respondents having adopted the innovation, predominantly e-commerce platforms (75%), and few having taken up big data analytics (4.72%) and the IoT (3%). Of the 4IR adopters, 54% (58) reported a positive link to SCR, whilst the rest (49) were undecided.

The adoption of 4IR technologies amongst Zimbabwean SMEs remains low, despite the distinct benefits. The low uptake is possibly attributed to the lack of internet-enabled devices, high prices of internet services that are beyond the reach of many, smartphones and mobile data and low digital literacy skills, together with ignorance on the part of SME owners and managers. Notwithstanding, SMEs expanded the use of 4IR technologies, especially e-commerce and big data in response to the pandemic. A greater proportion of 4IR technology adopters are from the mining, agriculture, manufacturing and hospitality sectors. Additional evidence indicates that SMEs with higher technological levels before COVID-19 are more likely to intensify digitalisation in response to the pandemic and have increased sales, employment and resilience.

Also, in response to the COVID-19 pandemic-induced disruptions, SMEs have had to adjust their employment structures by reducing working hours and wages rather than laying off employees. If the pandemic continues, the SMEs are more likely to reduce working hours (45%), grant leave of absence (32%) and reduce wages (37%) in response to the economic shock. In terms of the impact of the pandemic, on average, sales revenues have contracted by 50% since the onset of COVID-19, mainly as a result of supply chain disruptions.

Construct reliability

The study measured the reliability of the questionnaire constructs using the Cronbach alpha, wherein the alpha coefficient for the research items is 0.839, suggesting that the items have relatively high internal consistency in line with the literature (Bonett & Wright 2014; Taber 2018).

Normality test

In order to assess whether data were normally distributed, two statistical tests of normality using SPSS were performed, namely Kolmogorov–Smirnov and Shapiro–Wilk. The results displayed in Table 3 reveal that significance values are greater than the alpha value of 0.05 (0.201 and 0.117 respectively), indicating that the data are normally distributed (Puan et al. 2019).

Exploratory factor analysis

The study employed the exploratory factor analysis (EFA) technique as a variable-reduction tool for the survey data set to parsimoniously determine the essential control variables for use in the binary logit regression model. The EFA involved the correlation matrix, Kaiser-Meyer-Olkin (KMO) and Bartlett's test, communalities and communalities total variance extractions.

TABLE 3: Normality tests.

Variable	Kolmogorov–Smirnov†			Shapiro–Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Have you adopted any 4IR technology during COVID-19?	0.094	249	0.201‡	0.849	249	0.117

†, Lilliefors significance correction.

‡, This is a lower bound of the true significance.

TABLE 5: Kaiser–Meyer–Olkin and Bartlett's test.

Measure	Value
Kaiser–Meyer–Olkin measure of sampling adequacy	0.741
Bartlett's test of sphericity	
Approx. chi-square	2144.051
df	-
Sig.	0.000

TABLE 4: Correlation matrix.

Variable	Correlation matrix†,‡						ICT ease of use	Gender	Education
	SME age	Personal innovativeness	ICT literacy	Owner or manager's age	Costs	Security			
Sig. (1-tailed)									
SME age	-	0.000	0.000	0.000	0.015	0.000	0.000	0.000	0.000
Personal innovativeness	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ICT literacy	0.000	0.000	-	0.000	0.070	0.000	0.000	0.000	0.000
Owner or manager age	0.000	0.000	0.000	-	0.000	0.012	0.000	0.000	0.000
Costs	0.015	0.000	0.070	0.000	-	0.000	0.000	0.000	0.000
Security	0.000	0.000	0.000	0.012	0.000	-	0.000	0.000	0.000
ICT ease of use	0.000	0.000	0.000	0.000	0.000	0.000	-	0.000	0.000
Gender	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	0.000
Education	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-

SME, small and medium enterprise; ICT, information and communication technology.

†, Determinant = 0.531.

‡, Tested at the 0.05 level of significance.

Correlation matrix

The correlation matrix represents a simple rectangular array of numbers that provides the correlation coefficients between a single variable and every other variable in the study (Beckman & Quarles 1956). The Pearson correlations are computed to ascertain relationships between the independent and dependent variables (Seate, Pooe & Chinomona 2016). The correlation matrix for the cross-sectional survey data set of the Zimbabwean SMEs is shown in Table 4.

As shown in Table 4, the determinant of the correlation coefficients was 0.531, indicating the absence of computational difficulties. Therefore, consistent with Tripepi et al. (2008), it can be inferred that the model to be used for analysis is good. Thereafter, the KMO and Bartlett's tests were employed to test for ample adequacy with the results displayed in Table 5.

As shown in Table 5, a KMO measure of 0.741 therefore suggests that this study's sample was adequate, permitting EFA, in line with Kaiser's (1974) recommendation of values between 0.7 and 0.8. The table also displays a Bartlett's test of sphericity's *p*-value of 0.00 at the 5% significance level, indicating that the EFA procedure was valid and allowed for further analysis.

Communality

Communality, also referred to as h^2 describes the common variance of extracted factors ranging between 0 and 1. The closer the values are to 1, extracted factors account for a greater amount of the variance of a particular individual item (Grimm & Yarnold 1995). Table 6 presents the study's communalities that were selected for further analysis in the study. Communality values of these variables following extraction were greater than 0.5.

TABLE 6: Communalities.

Variable	Initial	After extraction
SME age	1.000	0.591
Personal innovativeness	1.000	0.746
ICT literacy	1.000	0.636
SME owner or manager's age	1.000	0.572
Costs	1.000	0.750
Security	1.000	0.618
ICT ease of use	1.000	0.862
Gender	1.000	0.739
Education	1.000	0.627

Extraction method: exploratory factor analysis.
SME, small and medium enterprise; ICT, information and communication technology.

Table 7 shows the components extracted through the principal component analysis procedure by their eigenvalues.

Not all the control variables recommended by the literature and availed in the survey data set were retained for data analysis. As shown in Table 7, only three

TABLE 8a: Logit model.

Measure	Chi-square	df	Sig.	−2 Log likelihood	Cox and Snell R^2	Nagelkerke R^2
Omnibus tests of model coefficients						
Step 1						
Step	1821.051	9	0.000	-	-	-
Block	1821.051	9	0.000	-	-	-
Model	1821.051	9	0.000	-	-	-
Model summary						
Step 1	-	-	-	3556.008†	0.682	0.839
Hosmer and Lemeshow test						
Step 1	6.059	9	0.702	-	-	-

†, Estimation terminated at iteration number 4 because parameter estimates changed by < 0.001.

TABLE 8b: Logit model.

Observed	Predicted		
	Non-adoption of 4IR technology	4IR technology adoption	Percentage correct
Classification table‡			
Step 1	-	-	-
4IR adoption	-	-	-
Non-adoption of 4IR	142	107	86.9
4IR adoption	0	5	100.0
Overall percentage	-	-	91.7

4IR, Fourth Industrial Revolution.
‡, The cut-off value is 0.500.

TABLE 8c: Logit model.

Variable	B	SE	Wald	df	Sig.	Exp(B)
Variables in the equation						
Step 1§						
SME age	−1.422	0.480	19.421	1	0.601	0.241
Personal innovativeness	1.207	0.395	15.779	1	0.001	3.343
Owner or manager ICT literacy	0.751	0.301	8.073	1	0.000	2.119
Owner or manager's age	−0.839	0.408	7.052	1	0.759	0.432
Gender	−0.613	0.286	7.490	1	0.692	0.542
Education	0.925	0.339	5.228	1	0.000	2.522
Costs	−0.501	2.011	6.963	1	0.003	0.606
Security	0.694	0.713	4.086	1	0.001	2.002
ICT ease of use	0.720	0.414	7.009	1	0.000	2.054
Constant	0.201	0.307	4.751	1	0.000	1.222

SE, standard error; SME, small and medium enterprise; ICT, information and communication technology.
§, Variable(s) entered on step 1: SME age × personal innovativeness, owner or manager ICT literacy, owner or manager's age, gender, education, costs, security, ICT ease of use.

TABLE 7: Component total variance explained.

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	1.841	35.267	35.267	1.841	35.267	35.267	1.805	34.730	34.730
2	1.290	21.401	56.668	1.290	21.401	56.668	1.274	20.802	55.532
3	1.097	19.825	76.493	1.097	19.825	76.493	1.109	21.116	76.648
4	0.709	11.502	87.995	-	-	-	-	-	-
5	0.601	9.417	97.412	-	-	-	-	-	-
6	0.338	2.588	100.000	-	-	-	-	-	-

Extraction method: exploratory factor analysis.

TABLE 9: Chi-square on small and medium enterprise Fourth Industrial Revolution adoption and supply chain resilience.

Measure	Value	*df*	Asymptotic significance (two-sided)
Chi-square: SME 4IR adoption and SCR			
Pearson chi-square	123.836†	1	0.000
Continuity correction‡	121.419	1	0.000
Likelihood ratio	43.720	1	0.000
Linear-by-linear association	9.204	1	0.000
N of valid cases	58	-	-

SME, small and medium enterprise; SCR, supply chain resilience; 4IR, Fourth Industrial Revolution.

†, 0 cells (0.0) have expected count less than 5. The minimum expected count is 18.00.

‡, Computed only for a 2 × 2 table.

components whose eigenvalues were greater than 1.00 were selected through variable combination. The first component accounts for the greatest proportion of variance, and hence, had the highest eigenvalues. The next component explained as much of the remaining variance as it could, all up to the final component. The first three components cumulatively accounted for 76.5% of the total variance. Component 1 explained 35.27% of the total variance, Component 2 accounted for 21.40% and Component 3 constituted 19.83%, whilst the remaining three components represented 23.5%. Thereafter, we proceeded to estimate the logit model, as shown in Table 8.

The Omnibus tests of model coefficients is a goodness-of-fit test, which 'gives an overall indication of how well the model performs over the one with none of the predictors entered into the model' (Palliant 2010). As shown in Table 8, the Omnibus tests of model coefficients display a *p*-value of 0.000, and therefore is statistically significant at the 95% confidence level. Thus, the Omnibus tests of model coefficients' chi-square statistic shows that all variables considered in the model were significant determinants of 4IR technology adoption amongst Zimbabwean SMEs. From the model summary in Table 8, the Nagelkerke R^2 statistic indicates that the model consisting of SME age, personal innovativeness, owner or manager ICT literacy, owner or manager age, costs, security and ICT as independent variables represents 83.9% of the total amount of variance in the SMEs' 4IR technology adoption decision. The Nagelkerke R^2 values provide an indication of the amount of variation in the dependent variable explained by the model (Palliant 2010). The Nagelkerke R^2 value suggests a good model fit, as only 16.1% of the variance in SME 4IR adoption is accounted for by other variables, which are not in the model.

At a 95% confidence level, the Hosmer–Lemeshow test is not statistically significant (p = 0.702). However, with a *p*-value greater than the 0.05 significance level, the logit regression model is an adequate fit to the data (Hosmer & Lemeshow 2000). The classification of the false positive and false negative error rates shown in Table 8 shows that the decision rule predicts a decision to adopt 4IR technology 112 times, and the prediction was wrong only five times. Therefore, there is a false positive of 4.5% (5/112). The decision rule predicted the non-adoption of mobile money 142 times, and that prediction was correct, making a false negative of 0% (0/142), with an overall model correct classification of 91.7%.

The Wald test in the variables in the equation section of Table 8 shows that at both the 5% and 10% significance levels, SME age, owner or manager age and gender are statistically significant in determining 4IR adoption amongst Zimbabwean SMEs. The dominant variables include personal innovativeness, owner or manager ICT literacy, education, costs, security and ICT ease of use. The coefficients of these variables are all statistically significant at the 95% confidence level, implying that they are significant predictors of 4IR technology adoption amongst Zimbabwean SMEs. Thus, the fitted logit model equation for the study is as follows:

$$\text{4IR technology adoption} = 0.201 - 1.422 \times \text{SME age} + 1.207 \times \text{personal innovativeness} + 0.751 \times \text{owner or manager ICT literacy} - 0.839 \times \text{owner or manager age} - 0.613 \times \text{gender} + 0.925 \times \text{education} - 0.501 \times \text{costs} + 0.694 \times \text{security} + 0.720\ \text{ICT ease of use}. \quad \text{[Eqn 4]}$$

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The relationship between the SME 4IR adoption and SCR was tested using a chi-square test, and the results are displayed in Table 9.

As shown in Table 9, the chi-square statistic reports a *p*-value of 0.000, which is less than the 5% significance level. Consequently, the study therefore rejects the null hypothesis. Evidence from the sample indicates that there is a statistically significant association (n = 58; p = 0.000) between SME owner or manager's adoption and SCR.

Conclusion

This study investigated the effect of 4IR technologies on SMEs' SCR amidst the COVID-19-induced disruptions from a developing country's perspective. The results thereof indicate that the adoption of 4IR technology significantly promotes much needed SME SCR. This finding corroborates studies conducted by BDO (2020), Thukral (2021), McKinsey (2020), Ivanov and Das (2020) and Schatteman, Woodhouse and Terino (2020). Consistent with the literature reviewed, the study concludes that personal innovativeness, ICT literacy, education and security promote, whilst costs inhibit the adoption of 4IR technology by an SME's owner or manager (Amornkitvikai & Lee 2020; Chang & Dasgupta 2015; Mwai 2016; Nugroho et al. 2017).

Furthermore, this study revealed that adoption of 4IR technology is low despite the clear benefits amidst the COVID-19 pandemic. Only 43% of the respondents reported having taken up 4IR technology, mainly the e-commerce platforms, whilst a small proportion had

adopted big data analytics and the IoT. The low levels of 4IR technology adoption are because of a lack of internet-enabled devices, high prices of internet access services, low digital literacy skills and ignorance of the SME owners and managers. Without meaningful efforts to build SCR in the face of COVID-19, many SMEs in Zimbabwe will fold owing given their current susceptibility to the pandemic's effects. The above findings, therefore, suggest an urgent call for cost-effective yet sustainable means of advancing SMEs' adoption of 4IR technology to their foster SCR and ensure their survival during and after the COVID-19 pandemic.

This study contributes to the nascent literature on 4IR technology adoption and SCR from a developing country's perspective. The key concerns raised herein for SMEs are twofold: how to effectively overcome the adoption barriers and relaying critical information to SME owners and/or managers on the merits of 4IR technology. Premised on this study's findings, the following recommendations are made for government and other relevant stakeholders. Firstly, we advocate for the merging of promotional efforts made by government and private sector through different media to educate SMEs on SCR and the benefits of 4IR technology adoption. This collaborative effort would accelerate adoption of 4IR technology as e-commerce platforms, which have proved to be popular amongst the respondents, whilst raising awareness of other technologies such as AI, IoT and big data that are yet to gain traction yet are critical in fostering SCR amongst local SMEs. Secondly, we advocate for consultations with telecommunication providers to undertake outreaches to improve ICT literacy amongst SMEs. Thirdly, government and internet connection service providers need to reconsider the current exorbitant internet connectivity costs, which are currently discouraging many from adoption. Fourthly, the government needs to make provision of tax holidays and/or subsidies to SMEs for importing ICT equipment, which facilitates 4IR to encourage adoption thereof.

Whilst this study offered valuable insights into the 4IR technology adoption and SCR nexus and policy implications from a developing country's perspective, it is not without its limitations. Firstly, the study collected data during the period when movement was restricted because of COVID-19. As a result, we resorted to an online questionnaire, which limited our observation of the respondents' use of 4IR technology. This could possibly have qualitatively enriched the responses obtained from the study. Secondly, the study was limited in terms of its sample size; from across 10 provinces in Zimbabwe, we obtained responses from 318 SMEs. Thirdly, because of resource constraints the study managed to collect and analyse survey data from only at a single point in time, without a nuanced trend analysis. It is recommended that future studies employ a stratified random sampling method to ensure increased participation by SMEs from all the country's provinces. In addition to the questionnaire, interviews can be utilised to effectively capture the qualitative aspects of the study. Future studies can also undertake a longitudinal survey that captures the 4IR technology adoption and SMEs' resilience trends over time, which, in turn, would assist in implementing dynamic policy changes.

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Competing interests

The authors declare no competing interest exists.

Authors' contributions

S.M. conceptualised and drafted the manuscript, whilst D.P. conceptualised, corrected and edited the article.

Ethical considerations

This study followed all ethical standards for research without direct contact with human or animal subjects.

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Data availability

The data that support the findings of this study are available on request from the corresponding author, D.P.

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