RESEARCH

Technology adoption as survival strategy for small and medium enterprises during COVID-19

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Abstract

Globally, operational capabilities of small and medium enterprises (SMEs) have been immensely affected by the COVID-19 pandemic, forcing many companies to use technology and innovation rather than the more traditional methods of operations. As the extent to which SMEs' adoption of technological tools is still unknown, this study assesses the technological transformations and the challenges facing SMEs during the pandemic. It also evaluates the levels of customers satisfaction and future technological innovation plans in SMEs. Using quantitative and qualitative primary date, we empirically examine how COVID-19 lockdowns accelerated technology use in Omani SMEs and test eight hypotheses applying paired *t* test and Pearson's correlation. Although the impact of the COVID-19 pandemic has been globally felt, this study focuses on the effect of the pandemic on SMEs operating in the logistics and supply chain sector in the Sultanate of Oman. The primary data used was collected through the survey questionnaire and interviews with business owners and company executives covering the period 2020–2021. The results show strong correlations between technology use before and during COVID-19; technology use during COVID-19 and in future; and technology use before COVID-19 and in future. They also reveal that technology adoption has been a successful persistence strategy during the pandemic and that highly digitized SMEs are more likely to adopt industry 4.0 technology. The findings are expected to have practical implications for policy making by investing and developing digital infrastructure to accelerate digital transformation, while company executives appreciating the requirements and benefits of adopting innovation and technology solutions to remain competitive. We acknowledge the limitation of our study to only SMEs in the Sultanate of Oman and within a short period of time during the COVID-19 pandemic. This makes it hard to generalize our findings; hence, we recommend further research in other business sectors and countries in the post-pandemic to corroborate our findings and compare outcomes. To the best of the authors' knowledge, no research has been done on SMEs that consider technological transformation during COVID-19. The study will advance knowledge of the development and adoption of technology in SMEs, as well as their impacts on productivity and efficiency.

Keywords: Small and Medium Enterprises, Technology adoption, COVID-19, Operation, Impact

Introduction

Small and Medium size Enterprises (SMEs) have been negatively affected by the outbreak of COVID-19. Enforced lockdowns, limited demand and low purchasing power resulted in huge financial losses and even closures of many companies. Fairlie (2020) realized this outcome at the early phase of the pandmeic, arguing that the number of active small businesses reduced by 22% in the United States between February and April 2020. Other scholars examined the economic impact of financial losses and closures of SMEs during the pandemic by arguing that a country's economic growth largely depends on its SMEs (Belsito & Reutzel, 2019; Didonet & Diaz-Villavicencio, 2020; Na-Nan & Wongsuwan, 2020; Rafiki, 2020). Zafar and Mustafa (2017) echoed this argument by stressing that SMEs in high-income countries contribute to over 55% of GDP and over 65% of total employment, while in low-income nations, their contribution goes up to 60% of GDP and 70% of total employment. The contribution of SMEs to socio-economic development is higher in middle-income countries, averaging 70% of GDP and approximately 95% of total employment.

Despite the underlying efforts by governments to support SMEs by providing stimulus programs and other fiscal and technical assistance to keep these companies afloat during the pandemic, it is difficult to ensure that SMEs will endure if the negative impacts continue and that most of these companies suffer long-term pandemic effects, if not facing an uncertain future (Bartik et al., 2020a, 2020c). Lu et al. (2020) expressed similar concerns, arguing that although China was first to recover from the pandemic, SMEs still face considerable risks associated with the pandemic.

Although many analysts such as Juergensen et al. (2020) and Pedauga et al. (2021) recommended government financial support to SMEs, we believe that innovation and technology are essential tools to bring about desperately needed changes for SMEs. Indeed, innovation and technology can lead SMEs to superior performance and competitive advantage. Innovation practices proved effective in improving performance (Adam & Alarifi, 2021). However, our initial investigation shows that only 11 studies examined the role of technology in developed countries and that there is a large research gap on the digital transformation of SMEs in developing countries (Amornkitvikai & Lee, 2020; Hassen et al., 2019). During the COVID-19 pandemic, we have noticed that the endurance of large companies depends on the ability to adapt to new market mechanisms in a way that helps them to gain a competitive advantage in the global market (Baporikar & Shikokola, 2020). Consumers were able to continue many of their tasks with the help of Amazon, Google Cloud, Facebook, Microsoft Azure, Zoom, Netflix, and Slack. However, many small companies could not grasp the benefits of digitization and had not acquired the digital skills for running their businesses online (Antonescu, 2020).

There is a higher probability of SMEs adopting technology once they realize the benefits and impact on performance (Scupola, 2009; Shah Alam et al., 2011). This probability should be tested in the context of developing countries, where SMEs play a major role in socio-economic development. Abed (2021) systematically reviewed the literature on the role of technology in reducing the effect of the pandemic on enterprises. Although he found that technology was an essential element in SMEs' persistence in developed countries, he stressed the lack of research in Middle East countries, except only one study Salem and Nor (2020), who investigated SMEs and technology use in Saudi Arabia

during COVID-19. Billore and Billore (2020), Doyle and Conboy (2020) and Salem and Nor (2020) also stressed the lack of empirical research in this aspect, suggesting further assessing the role of technology adoption in the survival of SMEs during COVID-19.

This study builds on the findings of previous studies conducted by Magd and McCoy (2014), Afifi and Negm (2020), and Ali and Mukhaini (2020), who concluded that SMEs needed to significantly improve in technological innovation if they are to flourish. It aims to provide a better understanding of the current technological transformations in Omani SMEs and the challenges these companies face. It also investigates the levels of satisfaction and future technological innovation plans in SMEs. While conducting our analysis, this study seeks to answer the following research questions: (1) how has COVID-19 accelerated technological transformation and adoption of new technologies by SMEs during the pandemic? And (2) How has technological transformation helped SMEs to manage their operations during the COVID-19 crisis? In doing so, the study adopts a mixed method approach to collect and analyze primary data gathered from surveying 214 SMEs and 10 interviews with business owners and company executives across the Sultanate of Oman between February and April 2021.

Our study makes original contributions as it improves our understanding of the role of technology adoption as a survival strategy for SMEs during the time of crises, as well as helping SMEs owners and executives to realize the importance of digital transformation in enhancing the company operations and performance in an increasingly competitive marketplace. This study also makes interesting linkages between the use of technology and company performance before, during, and after COVID-19, while stressing that digitized SMEs are highly likely to adopt industry 4.0 technologies in the future. Moreover, our study is expected to help researchers and policy makers in Oman and other developing countries to develop innovative strategies that accelerate digital transformation and technology-driven policies in support of local SMEs. At a company level, our study is expected to help SMEs to recognize the demands and advantages of adopting Industry 4.0 technology to easily weather any negative consequences of similar crises of the scale of the COVID-19 pandemic.

This study encompasses six sections. Section "Literature review" conducts literature review through which several hypotheses are developed for testing. Section "Methodology" explains the appropriate research methods and tools employed for primary data collection and analysis. Section "Results" presents analysis and results. Section "Discussion" provides a stimulating discussion and debate of the findings. Section "Conclusion" explains the theoretical and practical implications of the study for knowledge and policymaking.

Literature review

Impact of COVID-19 lockdowns on SMEs

The COVID-19 lockdowns affected all kinds of enterprises, including restaurants, supermarkets, fitness centers, traditional food markets, cinemas, car dealerships, and any operations that required physical space as opposed to online markets. The pandemic also impacted investment, trade, and other economic activities across borders (Gössling et al., 2020), culminating in a decreased cash flow due to lesser consumer demand (Priyono et al., 2020). Verma and Gustafsson (2020) analyzed 107 published papers in

Scopus and summarized the business situation during COVID-19 lockdown into four categories: overall impact on business, technology, supply chain management, and service industry. Bartik et al. (2020b) surveyed over 5,800 small enterprises and revealed huge numbers of layoffs, closures, financial loss, and funding expectations. A qualitative study using interviews, conducted by Nyanga and Zirima (2020), found that SMEs encountered disrupted operations and employees' layoff due to COVID-19. Seetharaman (2020) found that decreased revenue in small enterprises led to redundancies.

In China, Lu et al. (2020) assessed 4,807 SMEs by conducting online surveys and interviews. Their study indicated that SMEs' operational problems were due to unavailability of materials, supply chain disruptions, unavailability of workforce, reduced market demand, and cash flow. Belghitar et al. (2021) examined the performance of a further 42,401 SMEs across 28 industries during COVID-19 and found that 59% of British SMEs had negative earnings and needed government financial support. Beraha and Duricin (2020) investigated the effect of lockdowns on Serbian SMEs using online surveys, which underlined the varying intensity on the pandemic on SMEs' daily operations. Scottish SMEs showed loss of revenue and the need for financial assistance for enterprises with higher risk of bankruptcy and closure (Brown, 2020). Antonescu (2020) highlighted negative impact of the pandemic on Romanian SMEs, while Javed and Ayaz (2020) anticipated slow growth, higher costs of production, and a more intense impact of the lockdown on Pakistan's SMEs.

Moreover, Ratnasingam et al. (2020) assessed the effect of the pandemic on 748 Malaysian SMEs and reported financial management and supply chain disruptions as the major challenges. Robinson and Kengatharan (2020) found from interviewing 14 SMEs in Sri Lanka that material shortages, a decline in the global and local demand for products and services, difficulties when repaying loans and interest, order cancellations, and a lack of savings are major challenges. Desbureaux et al. (2020) surveyed 456 households and 144 small firms in urban and rural areas in Nord Kivu and found a decline in the local economy. In short, the surveyed literature confirms that millions of SMEs have been deeply affected by the pandemic and hundreds of thousands are in the process of closure across the world.

Technology adoption by SMEs

While reviewing the literature that examined the strategies and role of technology in SME endurance, we identified several studies concerned with developing innovative business models, communication strategies, and adopting digital marketing. For example, Untaru and Han (2021), examined how business strategies are affected by differences in gender, age, education, and income level. They concluded that retailers should develop dissimilar communication strategies for different customer segments, in accordance with these targeted demographic profiles, hoping that this strategy could increase protective measures against COVID-19 and avoid too many losses. Thorgren and Williams (2020) examined 456 struggling SMEs to explore the survival strategies adopted during COVID-19. They found that most SMEs deferred investments, reduced labor costs and other expenses, and renegotiated the terms of contracts and loans. Omar et al. (2020) examined survival strategies adopted by Malaysian SMEs because of Movement

Control Order (MCO) and found changes in financial and marketing strategies. Digital Marketing positively contribute to the SME performance (AlKoliby, et al., 2023).

Technology use by SMEs before and during COVID-19

Fitriasari (2020) presented a business model for SMEs to handle pandemics. This model consists of product excellence, public behavior, and process reliability, as well as underlining factors necessary for digital transformation, such as digital skills, infrastructure testing, and tools adoption. In the case of Indonesian SMEs' business model, Priyono et al. (2020) investigated changes and digital transformations with the help of a multiple case study involving seven manufacturing enterprises. The result of data analysis demonstrated dissimilar degrees of digital transformation in SMEs with a high level of digital maturity, those experiencing liquidity issues with a low level of digital maturity, and SMEs with a very limited level of digital literacy. The findings of the above surveyed literature help us to propose the following hypothesis:

H1: *There is no correlation between technology use by SMEs before and during COVID-19.*

Technology use by SMEs before and during COVOD-19 and in future

Chatterjee et al. (2022) reported that companies involved in SME business operations during COVID-19 did not use the most recent technology. Hussain et al. (2021) assessed the impact of technological (relative advantage and technology readiness), organizational (cost of adoption and top management support), and environmental (government support and competitive pressure) factors on B2B e-commerce for manufacturing SMEs in Pakistan. This multi-group analysis of the collected data predicted significant impact of technological factors on B2B e-commerce. Amat and Ishak (2019) argued that the success of SMEs is determined by their ability to innovate, access to capital, networking, and use of technology. These findings lead us to propose the following hypotheses:

H2: *There is no correlation between technology use by SMEs before COVID-19 and in future.*

H3: *There is no correlation between technology uses by SMEs during COVID-19 and in future.*

Customers satisfaction and technology use by SMEs during COVID-19

Marin Bustamante (2020) reviewed the literature on the role of new technologies (big data and analytics, artificial intelligence, mobile payments, internet of things, and block chain) in business during the COVID-19 lockdowns. She revealed that 65 papers were published from 2011 to 2020 and no study was conducted on the influence of new technologies in firms' internationalization in the context of the COVID-19 pandemic. Luo (2021) conducted a study using Deep Recurrent Neural Network (DRNN) on clickstream information for exploring the effect of social networks and online shopping behavior on e-business performance during the pandemic. Results showed that this deep learning technique is effective in modelling consumer behavior, and the model was able to improve the profitability ratio by 98.5%, the performance ratio by 97.5%, the accuracy ratio by 96.7%, the prediction ratio by 97.9%, and to give

less error rate than other approaches by 11.3%. the outcome of these reviews helps us to propose the following hypothesis:

H4: There is no correlation between customer satisfaction and technology use by SMEs during COVID-19.

Customers satisfaction and SMEs' performance during COVID-19

Empirical studies in business and marketing show that the shopping habits of various regions have changed during the pandemic (Bartik et al., 2020a, 2020b) and that digital transformation requires moving from offline stores to online for consumer health, safety, and convenience. Electronic banking has the positive effect on the customer's satisfaction (Ayinaddis, et al., 2023). Fletcher and Griffiths (2020) suggested technology as the best solution for business sustainability during the pandemic. It is important for companies not to look at COVID-19 as an obstacle, since adoption of online digital channels can increase their promotion and sales (Doyle & Conboy, 2020). Each enterprise, whether large or small, is crucial for the economy, and therefore, their sustainability, by adopting technologies, is essential in the current and future environment (Ameen et al., 2021). These findings help us develop the following hypothesis:

H5: There is no correlation between customer satisfaction and SMEs' performance during COVID-19.

SMEs' company size and digitalization during COVID-19

During the COVID-19 crisis, FinTech companies helped workers, entrepreneurs, and entire economies. Smeets and Zeisberger (2020) underscored the benefits and use of FinTech in Latin America during this period. Simultaneously, Salem and Nor (2020) investigated consumer intention to adopt e-commerce in Saudi Arabia. The research empirically identified factors of perceived lack of alternatives, perceived behavioral control, and government support, which significantly influence the embracing of online spending. While analyzing the perceptions of 12 specialists on COVID-19 and information management, Dwivedi et al. (2020) found different perspectives regarding digital strategy, artificial intelligence, information management, social interactions, cyber security, big data, blockchain, privacy, mobile technology, and strategy. Khan and Al-Badi (2020b) and McKnight (2017) underscored the importance of Internet of Things (IoT), which refers to the connections of machines, computers, and people, enabling intelligent industrial operations for transformational business outcomes, with benefits of closed-loop design, increased consumer value, predictive maintenance, new service lines, and reduced labor cost. Attaran and Woods (2019) and Thames and Schaefer (2016) argued that the paradigm of cloud computing enables the leasing of computing resources in real-time, with minimal interaction with the provider for cost-saving, seamless implementation, and simplification. These outcomes help in proposing the following hypothesis:

H6: There is no correlation between SMEs' company size and digitalization during COVID-19.

Industry 4.0 technology use by SMEs during COVID-19 and in future

Big data technology aids in the exploitation of data and adds value to several supply chain-related tasks, while being useful for industrial and service companies' efforts to optimize their worldwide supply chains. Big data technology also facilitates the process of customizing customer, partner relationship management, and optimal resource use (Chatterjee et al., 2022). Big Data Analytics is a technology designed to economically extract value from massive volumes of a wide variety of data by enabling high-velocity capture, discovery, and analysis (Khan & Al-Badi, 2020a). This technology facilitates innovative and customer-centric post-sale services and offers feedback for better product design and marketing (Akpan et al., 2020). Big data and predictive and visual analytics enable complex business decisions, while Artificial Intelligence (AI) involves learning, reasoning, and self-correction. Computer Vision is an essential enabling technology that sensibly enhances the outcomes, acting as a unifying element in many applications and a facilitator and integrator of other techniques (Khan & Al-Habsi, 2020). The findings of the surveyed literature help in proposing the following hypothesis:

H7: There is no correlation between Industry 4.0 technology use by SMEs during COVID-19 and in future.

Technology use by SMEs before and during COVID-19

Although Papadopoulos et al. (2020) examine the role of digital technologies in improving productivity and performance in SMEs during COVID-19; they stressed the lack of research on the use and adoption of these technologies to deal with the challenges of the pandemic. Their paper further highlights issues of infrastructure, finance, skilled workforce, and security constraints. After proposing a digital transformation and sustainability framework for SMEs to handle pandemics, Winarsih et al. (2021) reported lack of knowledge amongst enterprises on the benefits of digital skills. Jha (2020) interviewed the leaders of 15 Indian hi-tech startups from various industries on understanding the role of technology in business survival and revealed acceptance of new technologies and major transformation in the business model. These findings help in proposing the following hypothesis:

H8: There is no difference in the technology use by SMEs before and during COVID-19

In Bangladesh, Akter and Sultana (2020) surveyed 665 consumers on the attitude of digital marketing of branded cosmetics and discovered a positive attitude towards digital platforms during the lockdown. The difference is clear between digital and non-digital marking. Non-digital commerce involves a transaction of goods and services between buyers and sellers (Alharbi & de Doncker, 2019; Taleby Ahvanooey et al. (2020), while e-business is described as an internet-based transaction (Galindo-Martín et al., 2019). Social media and e-commerce shops have seen growth during the pandemic and consumers regularly searched for essential products online. Companies are using social media and online techniques to distribute product information for sales and to predict revenue trends (Lv et al., 2020). The effectiveness of a social network-based e-business strategy is measured by how well consumers use retreats, likes, and shares to engage with the company's advertisements. Social networking is used in advertising and promotional activities (Sathishkumar et al., 2020) and online marketing (Kumari et al., 2020).

Methodology

Research philosophy

The research questions, objectives and hypotheses developed from surveying the broad literature on technology and SMEs require a comprehensive methodological approach to test the hypotheses and achieve the research objectives. We used a mixed method approach, encompassing both qualitative and quantitative techniques for data collection and in-depth analysis. Mixed research methods provide strengths to both quantitative and qualitative methods, enhancing the quality of the research, and allowing for the topic to be more explored and diverse (Shorten & Smith, 2017). Other benefits of this mixed approach are developing relationships between the research questions and results to reach coherent conclusions, enriching understanding of the business field (Molina-Azorin, 2016), and providing a very comprehensive and varied analysis through interviews and questionnaires.

Research design

Primary data were gathered using a survey questionnaire. The survey questions were repeatedly pilot tested to make it error free. The interview questions were also created to help the interviewees comprehend and perceive the difficulties they encountered throughout the pandemic. After conducting pilot interviews, the questions were repeatedly adjusted to ensure that they were appropriate for the interviewees and practical to gather the necessary data. The questions were derived from the gaps in the literature and hypotheses.

While seeking to answer the research questions specified in the introduction, we also aim to provide an explanation of the following intuitions: what level of digitalization do SMEs currently have? Which industry 4.0 technologies do SMEs plan to use in the future? What is the rate of company satisfaction with the quality of its E-Service? What is the rate of customer satisfaction with the quality of the company's e-service? In doing so, we employed a few research tools and statistical models to test the eight null hypotheses developed above.

Data collection methods

We used online and offline survey questionnaire and conducted interviews with executives of private and public sector companies between 10 February and 20 April 2021. Of the 230 companies surveyed, 214 valid survey data items were collected from respondents after review, data cleaning, removal of missing and incomplete values, and deletion of wrong responses. Either businesses who did not respond were shut down or the management provided an explanation, citing a variety of issues, such as time constraints, a busy workload, etc. A qualitative analysis of 10 interviews was also performed. The SPSS 26.0 and NVivo 12.0 software packages were used in data analysis, to establish the relationships between variables and constraints. Following data analysis, the results were brainstormed, then visualized as graphs and charts. We discussed and evaluated the results before final documentation. The characteristics and percentages of valid responses of the survey participants are listed in Table 1.

Table 1 Characteristics of survey participants and companies

Gender	Percent	Business Operation	Percent
Male	67.76	Oil and gas	0.93
Female	32.24	Electricity service	0.93
Total	100.00	Marine and fishing	0.93
Position	Percent	Food service	10.75
Director	41.59	Manufacturing	5.61
CEO	16.82	Finance	0.93
General manager	14.49	Healthcare	1.40
HR manager	1.40	Education	3.27
Finance manager	1.40	Travel and tourism	3.74
Operation manager	0.93	Social clubs	12.15
Employee	6.54	Media and entertainment	2.80
Other	16.82	Construction	14.02
Total	100.00	Logistics and supply chain	1.87
Number of offices	Percent	ICT	1.40
One	60.28	Wholesale (Food and others)	2.34
Two to five	33.18	Consultancy	2.80
Six to ten	3.74	Home business	7.94
More than ten	2.80	Sanad office	0.93
Total	100.00	Other	25.23
		Total	100.00

The paired *t* test and Pearson correlation were used here. The hypotheses were tested at $p < 0.01$ or $p < 0.05$. The correlation *r* values are: 0.00–0.19 "very weak"; 0.20–0.39 "weak"; 0.40–0.59 "moderate"; 0.60–0.79 "strong"; 0.80–1.0 "very strong" (Evans, 1996). The thematic and content approach was employed to generate the results of textual data and initial general themes were pre-determined before starting the coding process. These general themes (innovation, operation, and strategy) guided the analysis, but an open coding was also deployed for new emerging themes.

Pearson correlation coefficient (bivariate correlation): It is a measure of linear correlation between two sets of data. It does not only indicate the presence or absence of a correlation between two variables, but it also assists in determining the strength of the association between the two variables (Rice, 2006). It also determines the direction of correlation, or whether two variables have a negative or positive correlation. The Pearson correlation presupposes that data are sampled at random and that the variables have a continuous and normal distribution. The formula to calculate Pearson correlation is as follows:

$$r_{xy} = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n \sum x^2 - (\sum x)^2].[n \sum y^2 - (\sum y)^2]}} \tag{1}$$

where r = Pearson coefficient, n = number of the pairs of the stock, $\sum xy$ = sum of products of the paired stocks, $\sum x$ = sum of the x scores, $\sum y$ = sum of the y scores, $\sum x^2$ = sum of the squared x scores, $\sum y^2$ = sum of the squared y scores.

The 'r' can take on any value between '-1' and '+1'. The value '0' denotes that there is no link between the two variables. A value greater than '0' indicates a positive relationship

between two variables, suggesting that an increase in the value of one variable raises the value of the other. A value less than '0' indicates a negative relationship between two variables, indicating that raising the value of one decreases the value of the other.

T test: It is an inferential statistical analysis approach invented by William Sealy Gosset in 1908. A *t* test is conducted to see if there is a difference between the means of two groups that are related to some way (Kendall, 1946). The assumptions for *t* test distribution include random sampling, independent sampling of data from the same population, and normal distribution (e.g., tested applying Kolmogorov–Smirnov test). In addition, when the standard deviations of samples are almost equal, homogeneous, or equal, variance exists.

Paired *t* test (*t* test with correlation) examines the difference between two paired samples, i.e., the difference in the sample means used for a paired *t* test should be 0. It is used when the samples are made up of matched pairs of similar units, or when there are repeated measures. It is possible, for example, that the same object/entity will be examined multiple times—both before and after a treatment. This method can also be used in situations when the samples are related or have similar traits. The formula to calculate paired *t* test for two sample groups (1 and 2) is as follows:

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{S_1^2 + S_2^2 - 2\rho S_1 S_2}{n}}} \tag{2}$$

where n = sample size, $\overline{X_1}, \overline{X_2}$ = means of samples, $S_1{}^2, S_2{}^2$ = variance.

Results

We used a wide variety of companies and respondents for our data collection, sampling from public and private companies, Omani and non-Omani owners, male and female, local and international traders, and from CEOs to employees. The Cronbach alpha is 7.1, which is under the acceptable range. The surveyed companies comprise public (84.58%), private (11.21%), public–private (2.80%), and non-profit (1.40%), with offices in Muscat (37.85%), Al-Batinah South (7.48%), Al-Batinah North (39.25%), Al-Dakhaliyah (7.48%), Al-Buraimi (1.40%), Musandam (3.27%), Dhofar (1.40%), Al-Dhahirah (1.40%), Al-Wusta (0.47%). Most of these companies are more than 10 years (40.19%), some 3–5 years (27.57%), 6–10 years (19.63%), and less than 2 years (12.62%). They serve the public (49.53%), business-to-consumer (37.85%), and business-to-business (12.62%). Most of them trade locally and a few of them export goods. The Omani owners account for 90.19% and non-Omanis 9.81%. There are 67.76% male respondents and 32.24% female, their positions in the companies vary form Director, CEO, General Manager, HR Manager, Finance Manager, Operation Manager, to employee. Most of the SMEs have low level of digitization, such as payment via VISA card etc. For instance, high (e.g., using cloud system, online payment, and no printing (8.4%), moderate (e.g., cloud system, online payment, and less printing (22.9%), low (e.g., traditional way of communicating and cash/VISA payment only (68.7%). Figure 1 shows the level of digitization in SMEs in Oman.

The paired *t* test for technology use before and during the pandemic shows strong positive correlation ($r = 0.823$, $p < 0.01$) and there is a significant average difference
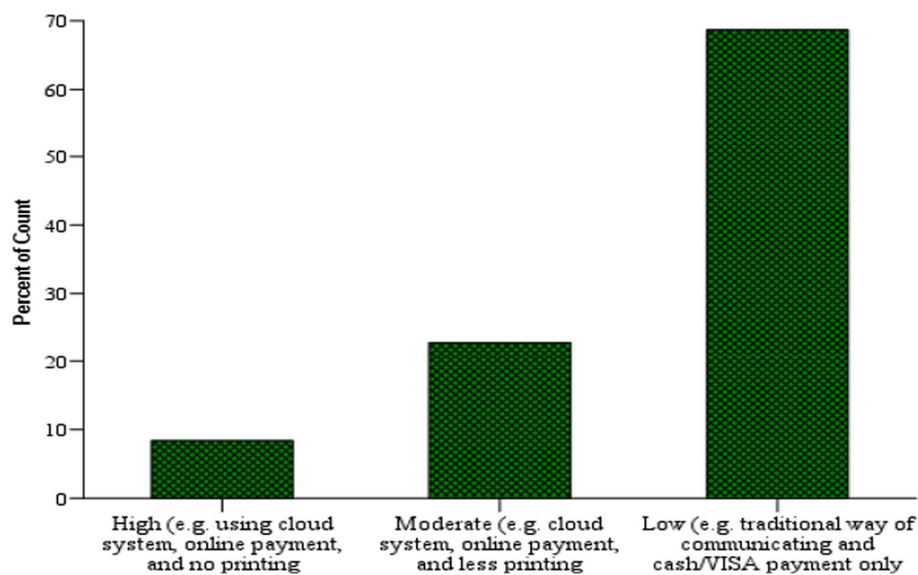
Fig. 1 Level of digitization in SMEs in Oman

between technology use before and during the pandemic (t_{213} = -2.153, $p < 0.05$). On average score technology use during COVID-19 was 13.1 points higher than technology use before the pandemic (95% CI [1.1, 25.1]). This indicates that the mean technology use score during COVID-19 ($M = 2.54$) was significantly higher than the mean before COVID-19 ($M = 2.41$). The technology use was independent of the number of branches and company's age. Table 2 shows Pearson's correlation matrix of selected variables.

There is strong correlation between technology use before and during COVID-19 ($r = 0.823$, $p < 0.01$), technology use during COVID-19 and in future (r = 0.659, $p < 0.01$), and technology use before the pandemic and in future ($r = 0.612$, $p < 0.01$). There is also correlation between customers satisfaction and sales ($r = 0.175$, $p < 0.05$) and technology use before COVID-19, during COVID-19, and in future ($r = 0.156$, $p < 0.05$; $r = 0.209$, $p < 0.01$; $r = 0.159$, $p < 0.05$). On further investigation, we learned that different SME owners and entrepreneurs found some innovative ways to overcome pandemic impacts and to reduce effects on their profits. Around half of the interviewees said that using technology such as e-marketing helped to reach out to the customers during the lockdown:

> *"Whatever I have done until today is almost enough to come out of any situations. To have more online communications with customers. Wherever I put my products, people online know about it. This type of communication is very important to come out of any situation. In addition, I am also planning to export outside the country. Also, we tied up with Mazoon Souq and online websites that charge for registration and commission as per the sale of the products. They pay you after 45 days." [RC034]*

Another interviewee explained how the pandemic helped the employees learn new technology and explore other tools even from outside Oman:

> *"We use a Russian software, and it is perfect for everything. We design innovative tools ourselves and the workers make them using machines." [T-RC024]*

Table 2 Pearson's correlation between selected variables

		Customer type	Type of business	Impact on performance	Impact on sales	Customer satisfaction	Technology use before pandemic	Technology use during pandemic	Technology use in future
Customer type	Pearson Correlation	1							
	Sig. (2-tailed)								
Type of business	Pearson Correlation	0.156*	1						
	Sig. (2-tailed)	0.023							
Impact on performance	Pearson Correlation	0.273**	0.173*	1					
	Sig. (2-tailed)	0	0.011						
Impact on sales	Pearson Correlation	0.127	-0.02	0.322**	1				
	Sig. (2-tailed)	0.063	0.776	0					
Customer satisfaction	Pearson Correlation	0.146*	0.143*	0.237**	-0.015	1			
	Sig. (2-tailed)	0.032	0.037	0	0.828				
Technology use before pandemic	Pearson Correlation	0.218**	0.139*	0.118	0.096	0.156*	1		
	Sig. (2-tailed)	0.001	0.042	0.084	0.164	0.023			
Technology use during pandemic	Pearson Correlation	0.203**	0.215**	0.138*	0.174*	0.209**	0.823**	1	
	Sig. (2-tailed)	0.003	0.002	0.044	0.011	0.002	0		
Technology use in future	Pearson Correlation	0.168*	0.159*	0.07	0.217**	0.159*	0.612**	0.659**	1
	Sig. (2-tailed)	0.014	0.02	0.305	0.001	0.02	0	0	

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

The customer and company have a high level of satisfaction with the eService. For instance, satisfaction of company from eService—strongly dissatisfied (6.1%), dissatisfied (9.8%), neutral (40.7%), satisfied (28.0%), and strongly satisfied (15.4%), Satisfaction of customer from eService—strongly dissatisfied (6.1%), dissatisfied (3.7%), neutral (43.0%), satisfied (28.5%), and strongly satisfied (18.7%). Figure 2 shows the satisfaction of customers and companies with eService during COVID-19.

In line with some recent studies that argue the pandemic has hastened technology transfer in various economic sectors, including SMEs, our data shows innovation development in business and SME sectors in Oman; this is a positive outcome of the pandemic. Our analysis supports the work of other scholars, who argue that
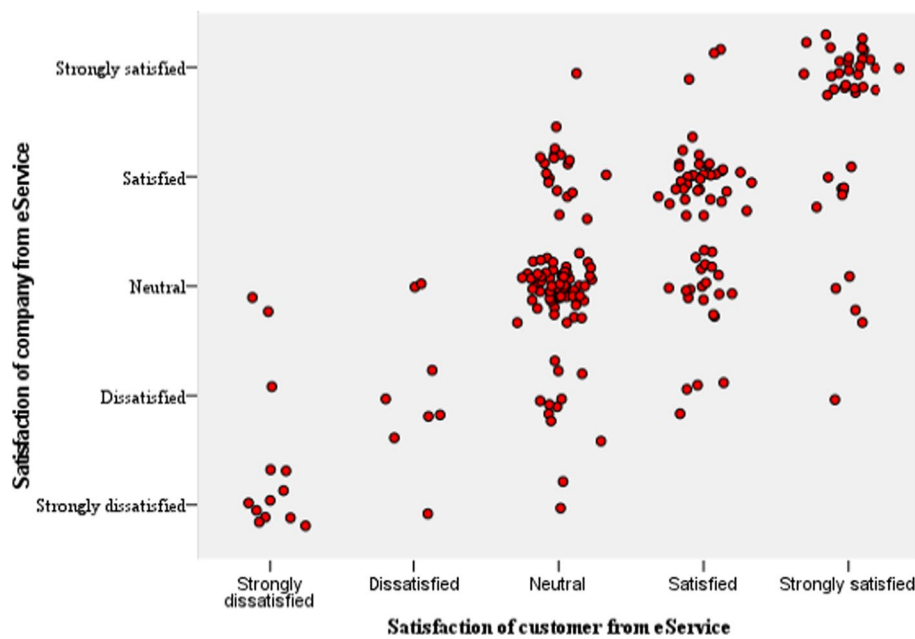
Fig. 2 Satisfaction of customers and companies with eService during COVID-19

innovative technologies, such as FinTech, which is a crowdfunding platform, does not only provide competitive advantages but also offer "a means for survival, by improvising existing business models" (Akpan et al., 2020, p. 7). Two of the interviewees mentioned the high cost of using technology and innovation in the present time; this could be attributable to the limited market access to innovation and technological solutions. Unfortunately, not many companies provide innovative products and services, as it is a new field in business and SME sectors. There are, however, many opportunities for new start-ups in innovation solutions that the private sector, entrepreneurs and even the government sector should consider.

Many businesses survived this pandemic by learning and adopting new technical strategies. For example, the business-to-business marketing strategy uses retailers sharing information about stock levels and involves technological collaboration between businesses of similar industrial sectors. Crick and Crick (2020) acknowledged that this helped to limit the negative impacts of COVID-19. A similar strategy of forming business alliances can be adopted to help the SMEs sector survive the pandemic in Oman. We questioned the respondents about the current state of industry 4.0 technology and future use and discovered there exists a strong correlation between the industry 4.0 technology current use and future use ($r = 0.322$, $p < 0.01$). One business owner's perception of industry 4.0 technology follows:

> "We are planning to invest in Artificial Intelligence, big data, machine learning, and biometrics soon. We will hire a consultant to help us improve in these areas. Our systems are ready for data analysis, so when we are ready to use it, we will be able to analyze the market and avoid technical problems." [T-RC024]

Table 3 Correlation between Industry 4.0 technology current and future use

	Level of digitalization	Industry 4.0 technology current use	Industry 4.0 technology use in future
Industry 4.0 technology current use			
Pearson correlation	0.322**		
Sig. (2-tailed)	0.000		
Industry 4.0 technology use in future			
Pearson correlation	0.226**	0.572**	
Sig. (2-tailed)	0.001	0.000	
Company size			
Pearson correlation	0.189**	0.106	0.113
Sig. (2-tailed)	0.006	0.123	0.099

** Correlation is significant at the 0.01 level (2-tailed)
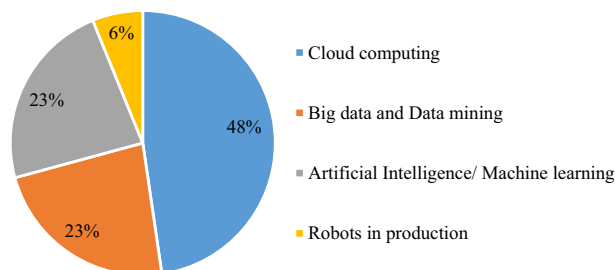
Fig. 3 Participants' willingness to use Industry 4.0 technology in terms of types and percentage

While the company size and level of digitalization are related, albeit weakly ($r = 0.189$, $p < 0.01$), this is not related to industry 4.0 technology current and future use. Table 3 shows this correlation.

The survey questionnaire analysis on the use of industry 4.0 technology in future found that more preference of cloud computing (48%), followed by Artificial Intelligence (23%), and big data (23%). Figure 3 shows the participants willingness to use industry 4.0 technology in terms of types and percentage.

Overcoming challenges during the pandemic have improved the strategies used in businesses and SMEs. Moreover, the strategizing skills of entrepreneurs and business owners have also advanced. Four out of ten interviewees confirmed that they had to change their strategy and explore new ones and, therefore, started learning new approaches to survive this pandemic. This entrepreneur said:

> *"We know Oman is a small market, and our technology is borderless. Since day one, we have been planning to sell our product aboard. We have already started to study the licenses and operation process in other countries, and we have already talked to some companies from GCC and maybe will reach agreement with some of them soon." [T-RC004]*

Our data show more issues related to operation than other themes. We found that the companies' operation ($r = 0.146$, $p < 0.01$) and performance ($r = 0.237$, $p < 0.01$) were
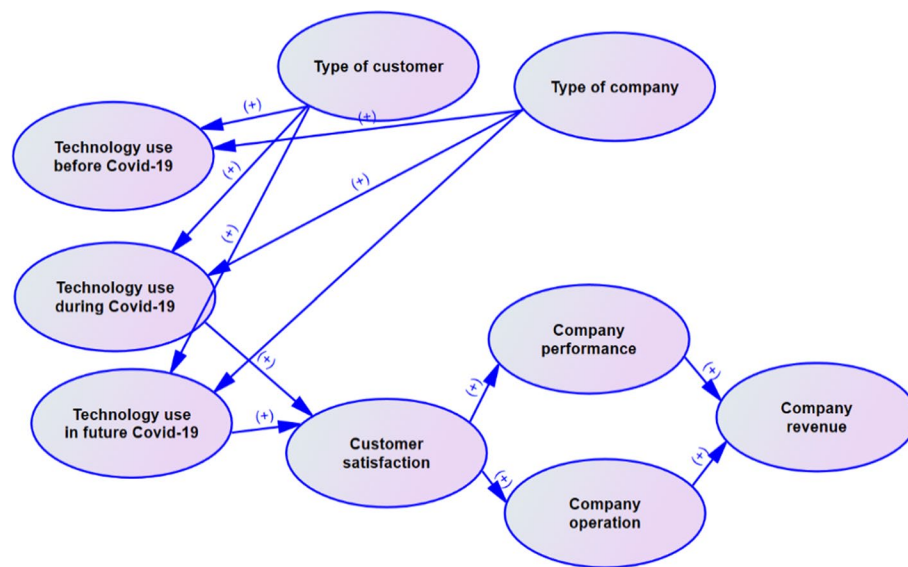
Fig. 4 Relationship between selected variables

Table 4 Results of hypotheses testing

Hypotheses	Correlation values	Accept/reject
H1: There is no correlation between technology use by SMEs before and during COVID-19	$r = 0.823, p < 0.01$	Reject
H2: There is no correlation between technology use by SMEs before COVID-19 and in future	$r = 0.612, p < 0.01$	Reject
H3: There is no correlation between technology use by SMEs during COVID-19 and in future	$r = 0.659, p < 0.01$	Reject
H4: There is no correlation between customer satisfaction and technology use by SMEs during COVID-19	$r = 0.209, p < 0.01$	Reject
H5: There is no correlation between customer satisfaction and SMEs performance during COVID-19	$r = 0.237, p < 0.01$	Reject
H6: There is no correlation between SMEs' company size and digitalization during COVID-19	$r = 0.189, p < 0.01$	Reject
H7: There is no correlation between Industry 4.0 technology use by SMEs during COVID-19 and in future	$r = 0.322, p < 0.01$	Reject
H8: There is no difference in the technology use by SMEs before and during COVID-19	$t_{213} = -2.153, p < 0.05$	Reject

influenced by customers' satisfaction. Revenue was affected due to operation ($r = 0.456$, $p < 0.01$), performance ($r = 0.299$, $p < 0.01$), and type of business/company ($r = 0.134$, $p < 0.05$).

In addition, risk of insolvency was associated with operation ($r = 0.468$, $p < 0.01$), performance ($r = 0.303$, $p < 0.01$), and revenues ($r = 0.313$, $p < 0.01$). Figure 4 shows the relationship between selected variables.

The null hypotheses (H1 to H8) proposed in the study are rejected. Table 4 shows the results of the hypotheses upon testing.

Discussion

It is clear from our study that SMEs acted swiftly, embracing measures, such as technology adoption and product and marketing innovations. The Government of Oman has been able to curtail the effects of the COVID-19 pandemic and responded well in the healthcare area; however, it needs to act quickly to prevent economic and societal devastation to SMEs in the country. Marin Bustamante (2020) carried out a literature review on the effects of new technologies (big data and analytics, artificial intelligence, mobile payments, the internet of things, and blockchain) on business during the COVID-19 lockdowns. The review found that 65 articles were released between 2011 and 2020, but no studies on how new technologies are influencing corporate worldwide in the wake of the COVID-19 epidemic were conducted. Luo (2021). Our study offers several insightful and potentially useful policy interventions, alongside practical implications for SMEs. The research recommends actions based on how the SMEs addressed and responded to the challenges presented during an unforeseen external shock. The pandemic has been an opportunity for SMEs to re-invent themselves by adopting modern technologies. Moreover, SMEs have less competition from foreign companies; thus, they can enhance production to meet local demands in the areas of manufacturing, food and beverage, and agriculture. The lessons learned include infrastructure development, technical investments, technology implementation, and technology adoption for enhancing SMEs efficiency through digital transformation.

Infrastructure and management support

Business owners and entrepreneurs now possess better strategic thinking abilities. Four out of ten people who were interviewed said they had to alter their strategy and consider new ones. As a result, they began learning new techniques to survive this pandemic. Winarsih et al. (2021) found that businesses were unaware of the advantages of having digital skills. Another respondent highlighted how the pandemic assisted the staff in exploring new tools and learning new technology, even from outside Oman. Oliveira and Martins (2010) declared the IT infrastructure and technical skills of employees to be crucial factors in an organization's success for technology innovation in the value chain. The implementation of technology in SMEs requires top management support (Singh et al., 2019). In addition, advanced IT infrastructure in these enterprises contributes more towards competition and position. Fletcher and Griffiths (2020) studied the digital transformation among businesses during the pandemic and concluded that there is a need to attain digital maturity, because less digitally mature organizations have greater fragility and a higher level of digital maturity among organizations allows greater flexibility.

Papadopoulos et al. (2020) highlighted the absence of study on the usage and acceptance of these technologies to address the issues of the pandemic, even though they examined the role of digital technologies in enhancing productivity and performance in SMEs during COVID-19. Their paper also discusses infrastructure, finance, skilled labor, and security-related issues. After recommending a framework for digital transformation and sustainability to help SMEs deal with pandemics,

Technological investment

The regulatory support from the government and financial support from commercial institutions could help SMEs in accepting and using the latest technologies for their operations. Two respondents brought up the high costs associated with adopting innovation and technology today; this may be because there is little market access for these types of products. Since it is a new industry in the business and SME sectors, there are sadly not many businesses offering innovative products and services. Usually, organizations complain of the high cost of technology adoption, although the relative advantage overshadows the conventional business processes (Shahzad et al., 2020). Promotion of financing schemes, training, reskilling, and development programs are needed in parallel with simplified financing and support centers at governorate and regional levels for legal and financial advice, human resources, digitization, and business model innovation. The surveyed organizations complained that technology adoption in SMEs is low due to higher cost and shortage of adequate funds. In developing countries, adoption cost of technology usage is a substantial factor for SMEs (Elahi & Hassanzadeh, 2009; Mohtaramzadeh et al., 2018). To improve the overall technology implementation and adoption climate significantly, the SMEs will need to address training, workshops, and aggressively follow the persuasion policies.

The view of an entrepreneur on industry 4.0 technology is positive and promises to make investments in big data, machine learning, biometrics, and artificial intelligence. When we asked the respondents about the current state of industry 4.0 technology and its intended future application, we found that there is a significant correlation between the two *(r = 0.322, p < 0.01)*. Although the size of the company and the degree of digitalization are weakly correlated *(r = 0.189, p < 0.01)*, this is unrelated to the current and future adoption of industry 4.0 technology.

Technology implementation

Our findings demonstrate innovative development in SME sectors in Oman; this result is consistent with several recent studies that claim the pandemic has accelerated technology transfer. Our research backs up the claims made by other academics that cutting-edge technologies, such as FinTech, offer competitive benefits in addition to improvising existing business models (Akpan et al., 2020: p. 7).

Digital transformation needs to be conducted continuously to sustain customer satisfaction and an edge over competitors. With digitization, as the volume of data grows, the enterprise needs to develop resources for data governance and management. There is a substantial average difference in technology use before and during the pandemic $(t_{213} = -2.153, p < 0.05)$ and there is a strong positive correlation between technology use before and during the epidemic *(r = 0.823, p < 0.01)*. Technology use during COVID-19 was, on average, 13.1 points greater than it was prior to the pandemic (95% CI [1.1, 25.1]). This suggests that the average score for technology use during COVID-19 (M = 2.54) was significantly higher than the average score prior to COVID-19 (M = 2.41). The number of branches and age of the company had no bearing on how much technology was used. Jha (2020) conducted interviews with the executives of 15 Indian high-tech startups from a variety of sectors to better understand the importance of technology in business survival. The results showed that new technologies were accepted and that the

business model had undergone significant change. Governments must support the digital transformation for SMEs and stakeholders, yet finance with supplementary funds for digitization, technology transfer, and innovation cannot be elucidated, since the number of affected SMEs remains unknown. According to the analysis of the survey questionnaire on industry 4.0 technology utilization in the future, cloud computing is preferred more (48%), followed by artificial intelligence (23%), and big data (23%).

By learning and implementing new technical solutions, several organizations were able to withstand this pandemic. For instance, the business-to-business marketing strategy takes advantage of merchants sharing stock level information and incorporates technical cooperation between companies in related industrial sectors. This, according to Crick and Crick (2020), helped to mitigate the harmful effects of COVID-19. To help the SMEs sector in Oman survive the epidemic, a similar business alliance-building approach can be used.

Technology adoption

The research revealed that SME owners and entrepreneurs used creative solutions to combat pandemic effects and lessen repercussions on their bottom lines in Oman. During the lockout, about half of the interviewees claimed that technologies such as e marketing helped them connect with customers. For instance, SME owners highlighted the use of online marketplaces, such as Mazoon Souq. In general, the way SMEs have been using digital solutions for eCommerce has completely changed. As a direct result of COVID-19, manufacturing firms in developed countries have moved from a conventional to an eCommerce business model (Shahzad et al., 2020), with Oman following suit and applying technological innovation. In Oman, SMEs adopted new strategies and business models, which ensured their survival and enabled them to market their products during the pandemic. This is consistent with the findings of Hussain et al. (2021), where his research team reported that industries changed their business model to online, helping them to remain competitive.

The eService has received positive feedback from both the client and the business. For instance, customer satisfaction with the company as reported by eService was neutral (40.7%), strongly satisfied (28.0%), unhappy (9.8%), strongly dissatisfied (6.1%), and dissatisfied (15.4%). Strongly dissatisfied (6.1%), dissatisfied (3.7%), neutral (43.0%), satisfied (28.5%), and strongly satisfied (18.7%) describe the customer's satisfaction with the eService. There is also correlation between customers satisfaction and sales ($r=0.175$, $p<0.05$) and technology use before COVID-19, during COVID-19, and in future ($r=0.156, p<0.05; r=0.209, p<0.01; r=0.159, p<0.05$).

In addition, the lockdown has forced many retail outlets worldwide to provide online shopping and this trend is expected to continue post pandemic. Development of online platforms for these enterprises to sell their products is required to provide support for domestic producers and local firms. eCommerce has created a competitive advantage, increased productivity, and improved scheduling for the number of staff, campaigns, acquisitions, and other costs. In an empirical study by Hussain et al. (2020), competitive pressure led to eCommerce adoption. Increased competitive pressure leads to more use of the information system in SMEs (Ocloo et al., 2018). Baporikar (2015) stressed that SMEs are the lifeblood of any economy. In this context, Oman should create a suitable

system for entrepreneurship, which is considered globally to be the raw fuel for creating jobs. Furthermore, considering Omani people have only two ways of securing a job, by entering the public or private sectors, entrepreneurship could be the third option for self-employment and youth employment. If the latter option is considered seriously, Omani SMEs can gradually lead in job creation.

Conclusion

This study underscores the importance of technology in business and economic development, especially where countries face economic situations emanating from crises such as COVID-19 or move fast towards the fourth industrial revolution. Cutting-edge technologies add competitive advantages by improving existing business models and business strategies drive the innovation and reengineering processes. The power of AI, machine learning, IoT, robots, and data analytics can be leveraged by businesses for sustainability, resilience, and improved business continuity. The COVID-19 pandemic forced SMEs to take up new strategies that effectively and efficiently added value to their businesses. This is illustrated through quantitative and qualitative analyses of technological transformation in SMEs in the context of the Sultanate of Oman.

Theoretical implications

Our study makes an original contribution to knowledge and policy making, with practical implications for company executives. Theoretically, this study improves our understanding of the tremendous challenges that SMEs have faced during the COVID-19 pandemic and the extent to which these challenges affected their operations, performance, and customers satisfaction. It also underscores the importance and role of technology in supporting SMEs during the pandemic, most notably the transfer of providing services, transactions, sales, and marketing from offline to online. It also demonstrates the connections between the use of technology prior to, during, and after COVID-19, as well as prior to the pandemic and in the future.

In terms of policymaking, our study underscores the role of the state in investing and developing digital infrastructure and in providing the appropriate digital and technological platforms and tools to enable SMEs to adopt innovation and technology solutions during the time of crises. The findings of our study are expected to help policy makers in Oman and other developing countries to appreciate, initiate, and implement policies conducive to fostering digital transformation. In Oman, our findings have been communicated with senior officials in the Public Authority of Small and Medium Enterprises Development to take the necessary measures to support SMEs in the recovery from the pandemic. Chief amongst the issues we discussed with the SMEs authority is the need to formulate policy measures and initiatives aimed at promoting and implementing digital transformation that support the SMEs sector. The study also underlines the need to introduce financial incentives or specially designed financial packages to help SMEs in adopting industry 4.0 technologies. We also stress that investing in digital transformation does not only enhance business performance and output, but it also contributes significantly to an improvement in the SMEs ecosystem and the business environment.

Managerial implications

As for practical implications, our study helps company executives to understand the requirements and benefits of adopting industry 4.0 technology. It informs company executives of the advantages of switching from the traditional to online services during the COVID-19. Technology adoption has not only been a successful survival strategy for SMEs during the pandemic, but it has also become a vital strategy for companies to develop their operational, financial, sales, and marketing strategies if they are to remain competitive. Our findings may encourage company executives to invest in digital technology, particularly cloud computing, big data analytics, and online platforms for marketing and transactions.

The lockdowns have accelerated, projected, and magnified the impact of technology. We found strong correlations between technologies uses pre-COVID-19, during COVID-19, and in future. The use of technology also leads to higher satisfaction among customers, sales, and SME performances. We also found that highly digitized SMEs are more likely to adopt industry 4.0 technologies in future.

Ideas for future research

Finally, our study acknowledges its own limitations by focusing only on Omani SMEs and the short duration of 18 months since the outbreak of COVID-19. It also realizes the emergence of several new COVID-19 strains that makes it difficult to have a firm conclusion on the technology acceleration rate and their impacts on SMEs. Thus, we suggest further examination of this issue with broader scope of analysis geographical coverage in the post-pandemic for comparison.

Abbreviations
AI   Artificial Intelligence
IoT   Internet of Things
SMEs   Small and Medium Enterprises

Availability of data and materials
Not applicable.

Declarations

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

References

Abed, S. S. (2021). A literature review exploring the role of technology in business survival during the COVID-19 lockdowns. *International Journal of Organizational Analysis*. https://doi.org/10.1108/IJOA-11-2020-2501

Adam, N. A., & Alarifi, G. (2021). Innovation practices for survival of small and medium enterprises (SMEs) in the COVID-19 times: The role of external support. *Journal of Innovation and Entrepreneurship, 10*(1), 15.

Afifi, G. M. H., & Negm, M. M. F. (2020). Geological sites as a safe resort for post-COVID-19 tourism: The case of Al Jabal Al Akhdar, Oman. *Journal of Environmental Management and Tourism, 11*(6), 1520–1536.

Akpan, I. J., Soopramanien, D., & Kwak, D.-H. (2020). Cutting-edge technologies for small business and innovation in the era of COVID-19 global health pandemic. *Journal of Small Business & Entrepreneurship*. https://doi.org/10.1080/08276331.2020.1799294

Akter, M., & Sultana, N. (2020). Digital marketing communication and consumer buying decision process in pandemic standpoint (COVID-19): An empirical study of Bangladeshi customers' in branded cosmetics perspective. *Open Journal of Business and Management, 8*(06), 2696.

Alharbi, A. S. M., & de Doncker, E. (2019). Twitter sentiment analysis with a deep neural network: An enhanced approach using user behavioral information. *Cognitive Systems Research, 54*, 50–61.

Ali, A., & Mukhaini, M. (2020). COVID-19 in the Gulf Special Coverage COVID-19 and Plummeting Oil Prices; a Time of Reckoning for Oman. (April).

AlKoliby, I. S. M., Abdullah, H. H., & Suki, N. M. (2023). Linking Knowledge Application, Digital Marketing, and Manufacturing SMEs' Sustainable Performance: The Mediating Role of Innovation. *Journal of Knowledge Economy*. https://doi.org/10.1007/s13132-023-01157-4

Amat, M., & Ishak, S. (2019). Faktor PSiKKIT: Pendorong inovasi pembungkusan dalam kalangan Industri Kecil dan Sederhana berasaskan perusahaan makanan. *Malaysian Journal of Society and Space*. https://doi.org/10.17576/geo-2019-1503-07

Ameen, N., Tarhini, A., Reppel, A., & Anand, A. (2021). Customer experiences in the age of artificial intelligence. *Computers in Human Behavior, 114*, 1–14.

Amornkitvikai, Y., & Lee, C. (2020). Determinants of E-Commerce Adoption and Utilisation by SMEs in Thailand.

Antonescu, D. (2020). Supporting small and medium size enterprises through the COVID-19 crisis in Romania. *Central European Journal of Geography and Sustainable Development, 2*(1), 38–57.

Attaran, M., & Woods, J. (2019). Cloud computing technology: Improving small business performance using the Internet. *Journal of Small Business and Entrepreneurship, 31*(6), 495–519.

Ayinaddis, S. G., Taye, B. A., & Yirsaw, B. G. (2023). Examining the effect of electronic banking service quality on customer satisfaction and loyalty: An implication for technological innovation. *Journal of Innovation and Entrepreneurship, 12*(1), 22.

Baporikar, N. (2015). Entrepreneurship in Sultanate of Oman. *International Journal of Asian Business and Information Management, 6*(4), 14–26.

Baporikar, N., & Shikokola, S. (2020). Information Technology Adoption Dynamics for SMEs in the Manufacturing Sector of Namibia. *International Journal of ICT Research in Africa and the Middle East (IJICTRAME), 9*(2), 60–77.

Bartik, A. W., Bertrand, M., Cullen, Z. B., Glaeser, E. L., Luca, M., & Stanton, C. T. (2020). *How are small businesses adjusting to COVID-19? Early evidence from a survey*. National Bureau of Economic Research.

Bartik, A. W., Bertrand, M., Cullen, Z. B., Glaeser, E. L., Luca, M., & Stanton, C. T. (2020c). *How are small businesses adjusting to COVID-19? early evidence from a survey* (No. 0898–2937): National Bureau of Economic Research.

Bartik, A. W., Bertrand, M., Cullen, Z., Glaeser, E. L., Luca, M., & Stanton, C. (2020a). The impact of COVID-19 on small business outcomes and expectations. *Proceedings of the National Academy of Sciences, 117*(30), 17656–17666.

Belghitar, Y., Moro, A., & Radić, N. (2021). When the rainy day is the worst hurricane ever: the effects of governmental policies on SMEs during COVID-19. *Small Business Economics*. https://doi.org/10.1007/s11187-021-00510-8

Belsito, C. A., & Reutzel, C. R. (2019). SME employee performance appraisal formalization and trust in leadership change. *International Journal of Organizational Analysis*. https://doi.org/10.1108/IJOA-07-2019-1832

Beraha, I., & Đuričin, S. (2020). The impact of COVID-19 crisis on medium-sized enterprises in Serbia. *Economic Analysis, 53*(1), 14–27.

Billore, S., & Billore, G. (2020). Consumption switch at haste: Insights from Indian low-income customers for adopting Fintech services due to the pandemic. *Transnational Marketing Journal, 8*(2), 197–218.

Brown, R. (2020). The impact of COVID-19 on Scottish small and medium-sized enterprises (SMEs): prognosis and policy prescription. *Fraser of Allander Economic Commentary, 44*(2).

Chatterjee, S., Chaudhuri, R., Shah, M., & Maheshwari, P. (2022). Big data driven innovation for sustaining SME supply chain operation in post COVID-19 scenario: Moderating role of SME technology leadership. *Computers and Industrial Engineering, 168*, 108058. https://doi.org/10.1016/j.cie.2022.108058

Crick, J. M., & Crick, D. (2020). Coopetition and COVID-19: Collaborative business-to-business marketing strategies in a pandemic crisis. *Industrial Marketing Management, 88*, 206–213.

Desbureaux, S., Kaota, A., Lunanga, E., Stoop, N., & Verpoorten, M. (2020). *COVID-19 vs. Ebola: Impact on households and SMEs in Nord Kivu, DR Congo*, 1–25.

Didonet, S., & Diaz-Villavicencio, G. (2020). Innovation management in market-oriented SMEs: learning and internal arrangements for innovation. *International Journal of Organizational Analysis*. https://doi.org/10.1108/IJOA-09-2019-1885

Doyle, R., & Conboy, K. (2020). The role of IS in the COVID-19 pandemic: A liquid-modern perspective. *International Journal of Information Management, 55*, 102184.

Dwivedi, Y. K., Hughes, D. L., Coombs, C., Constantiou, I., Duan, Y., Edwards, J. S., et al. (2020). Impact of COVID-19 pandemic on information management research and practice: Transforming education, work and life. *International Journal of Information Management, 55*, 102211.

Elahi, S., & Hassanzadeh, A. (2009). A framework for evaluating electronic commerce adoption in Iranian companies. *International Journal of Information Management, 29*(1), 27–36.

Evans, R. (1996). An analysis of Criterion Variables Reliability in Conjoint analysis. *Perceptual and Motor Skills, 82*(3), 988–990.

Fairlie, R. W. (2020). *The impact of COVID-19 on small business owners: Evidence of early-stage losses from the April 2020 current population survey.* National Bureau of Economic Research.

Fitriasari, F. (2020). How do Small and Medium Enterprise (SME) survive the COVID-19 outbreak? *Jurnal Inovasi Ekonomi, 5*(2), 53–62.

Fletcher, G., & Griffiths, M. (2020). Digital transformation during a lockdown. *International Journal of Information Management, 55*(2020), 1–3.

Galindo-Martín, M. Á., Castaño-Martínez, M. S., & Méndez-Picazo, M. T. (2019). Digital transformation, digital dividends and entrepreneurship: A quantitative analysis. *Journal of Business Research, 101*, 522–527.

Gössling, S., Scott, D., & Hall, C. M. (2020). Pandemics, tourism and global change: a rapid assessment of COVID-19. *Journal of Sustainable Tourism, 29*, 1–20.

Hassen, H., Abd Rahim, N. H., & Shah, A. (2019). Analysis of models for e-commerce adoption factors in developing countries. *International Journal on Perceptive and Cognitive Computing, 5*(2), 72–80.

Hussain, A., Shahzad, A., & Hassan, R. (2020). Organizational and Environmental Factors with the Mediating Role of E-Commerce and SME Performance. *Journal of Open Innovation: Technology, Market, and Complexity, 6*(4), 196.

Hussain, A., Shahzad, A., Hassan, R., & Doski, S. A. (2021). COVID-19 impact on B2B e-commerce: A multi-group analysis of sports and surgical SME's. *Pakistan Journal of Commerce and Social Sciences (PJCSS), 15*(1), 166–195.

Javed, S. A., & Ayaz, M. U. (2020). Projected impact of lockdown on SMEs in Pakistan.

Jha, C. (2020). *The Great Disruptive Transformation: The Impact of COVID-19 Crisis on Innovative Startups in India.* University of Gottenberg.

Juergensen, J., Guimón, J., & Narula, R. (2020). European SMEs amidst the COVID-19 crisis: Assessing impact and policy responses. *Journal of Industrial and Business Economics, 47*(3), 499–510.

Kendall, M. G. (1946) 'The advanced theory of statistics', *The advanced theory of statistics.,* No. 2nd Ed.

Khan, A. I., & Al-Badi, A. (2020a). emerging data sources in decision making and AI. *Procedia Computer Science, 177*, 318–323.

Khan, A. I., & Al-Badi, A. (2020b). Open source machine learning frameworks for industrial internet of things. *Procedia Computer Science, 170*, 571–577.

Khan, A. I., & Al-Habsi, S. (2020). Machine learning in computer vision. *Procedia Computer Science, 167*, 1444–1451.

Kumari, A., Behera, R. K., Sahoo, K. S., Nayyar, A., Kumar Luhach, A., & Prakash Sahoo, S. (2020). Supervised link prediction using structured-based feature extraction in social network. *Concurrency Computation*. https://doi.org/10.1002/cpe.5839

Lu, Y., Wu, J., Peng, J., & Lu, L. (2020). The perceived impact of the COVID-19 epidemic: Evidence from a sample of 4807 SMEs in Sichuan Province, China. *Environmental Hazards, 19*(4), 323–340.

Luo, C. (2021). Analyzing the impact of social networks and social behavior on electronic business during COVID-19 pandemic. *Information Processing & Management, 58*(5), 102667.

Lv, J., Wang, T., Wang, H., Yu, J., & Wang, Y. (2020). A SECPG model for purchase behavior analysis in social e-commerce environment. *International Journal of Communication Systems, 33*(6), 1–13.

Magd, H. A. E., & McCoy, M. P. (2014). Entrepreneurship in Oman: Paving the way for a sustainable future. *Procedia Economics and Finance, 15*(14), 1632–1640.

Marin Bustamante, D. F. (2020). *The role of new technologies in international business in the context of COVID-19: a literature review.* Politecnico, Milano.

McKnight, M. (2017). IoT, industry 4.0, industrial IoT why connected devices are the future of design. *KnE Engineering., 2*(2), 197–202.

Mohtaramzadeh, M., Ramayah, T., & Jun-Hwa, C. (2018). B2B e-commerce adoption in Iranian manufacturing companies: Analyzing the moderating role of organizational culture. *International Journal of Human-Computer Interaction, 34*(7), 621–639.

Molina-Azorin, J. F. (2016). Mixed methods research: An opportunity to improve our studies and our research skills. *European Journal of Management and Business Economics, 25*(2), 37–38.

Na-Nan, K., & Wongsuwan, N. (2020). Development and validation of perceived workplace support for small and medium-sized enterprise employees. *International Journal of Organizational Analysis*. https://doi.org/10.1108/IJOA-12-2018-1608

Nyanga, T., & Zirima, H. (2020). Reactions of small to medium enterprises in masvingo, zimbabwe to Covid 19: Implications on productivity. *Business Excellence and Management, 10*(1), 22–32.

Ocloo, C. E., Xuhua, H., Akaba, S., Addai, M., Worwui-Brown, D. K., & Spio-Kwofie, A. (2018). B2B E-commerce adoption amongst manufacturing SMEs: An evidence from Ghana. *Australian Journal of Economics and Management Sciences, 8*(1), 1.

Oliveira, T., & Martins, M. F. (2010). *Information technology adoption models at firm level: review of literature.* Paper presented at the The European Conference on Information Systems Management.

Omar, A. R. C., Ishak, S., & Jusoh, M. A. (2020). The impact of COVID-19 movement control order on SMEs' businesses and survival strategies. *Malaysian Journal of Society and Space, 16*(2), 139–150.

Papadopoulos, T., Baltas, K. N., & Balta, M. E. (2020). The use of digital technologies by small and medium enterprises during COVID-19: Implications for theory and practice. *International Journal of Information Management, 55*(2020), 1–4.

Pedauga, L., Sáez, F., & Delgado-Márquez, B. L. (2021). Macroeconomic lockdown and SMEs: the impact of the COVID-19 pandemic in Spain. *Small Business Economics*. https://doi.org/10.1007/s11187-021-00476-7

Priyono, A., Moin, A., & Putri, V. N. A. O. (2020). Identifying digital transformation paths in the business model of smes during the COVID-19 pandemic. *Journal of Open Innovation: Technology, Market, and Complexity, 6*(4), 1–22.

Rafiki, A. (2020). Determinants of SME growth: an empirical study in Saudi Arabia. *International Journal of Organizational Analysis*.

Ratnasingam, J., Khoo, A., Jegathesan, N., Wei, L. C., Latib, H. A., Thanasegaran, G., et al. (2020). How are small and medium enterprises in Malaysia's furniture industry coping with COVID-19 pandemic? Early evidences from a survey and recommendations for policymakers. *BioResources, 15*(3), 5951–5964.

Rice, J. A. (2006). *Mathematical statistics and data analysis*. Cengage Learning.

Robinson, J., & Kengatharan, N. (2020). Exploring the effect of COVID-19 on small and medium enterprises: Early evidence from Sri Lanka. *Journal of Applied Economics & Business Research, 10*(2), 115–124.

Salem, M. A., & Nor, K. M. (2020). The effect of COVID-19 on consumer behaviour in Saudi Arabia: Switching from brick and mortar stores to E-Commerce. *International Journal of Scientific & Technology Research, 9*(07), 15–28.

Sathishkumar, V. E., Agrawal, P., Park, J., & Cho, Y. (2020). Bike sharing demand prediction using multiheaded convolution neural networks. *Basic & Clinical Pharmacology & Toxicology, 126*, 264–265.

Scupola, A. (2009). SMEs'e-commerce adoption: perspectives from Denmark and Australia. *Journal of Enterprise Information Management*. https://doi.org/10.1108/17410390910932803

Seetharaman, P. (2020). Business models shifts: Impact of COVID-19. *International Journal of Information Management., 54*, 102173.

Shah Alam, S., Ali, M. Y., & Mohd Jani, M. F. (2011). An empirical study of factors affecting electronic commerce adoption among SMEs in Malaysia. *Journal of business economics and management, 12*(2), 375–399.

Shahzad, A., Hassan, R., Abdullah, N. I., Hussain, A., & Fareed, M. (2020). COVID-19 impact on e-commerce usage: An empirical evidence from Malaysian healthcare industry. *Humanities & Social Sciences Reviews, 8*(3), 599–609.

Shorten, A., & Smith, J. (2017). Mixed methods research: Expanding the evidence base. *Evidence-Based Nursing, 20*(3), 74–75.

Singh, J., Flaherty, K., Sohi, R. S., Deeter-Schmelz, D., Habel, J., Le Meunier-FitzHugh, K., et al. (2019). Sales profession and professionals in the age of digitization and artificial intelligence technologies: Concepts, priorities, and questions. *Journal of Personal Selling & Sales Management, 39*(1), 2–22.

Smeets, K., & Zeisberger, S. (2020). How FinTech can help Latin America to deal with economic challenges and the COVID-19 crisis. *SSRN Journal*. https://doi.org/10.2139/ssrn.3673240

Taleby Ahvanooey, M., Li, Q., Zhu, X., Alazab, M., & Zhang, J. (2020). ANiTW: A Novel Intelligent Text Watermarking technique for forensic identification of spurious information on social media. *Computers and Security, 90*, 101702.

Thames, L., & Schaefer, D. (2016). *Software-defined Cloud Manufacturing for Industry 4.0*. Paper presented at the Procedia CIRP.

Thorgren, S., & Williams, T. A. (2020). Staying alive during an unfolding crisis: How SMEs ward off impending disaster. *Journal of Business Venturing Insights, 14*, e00187.

Untaru, E. N., & Han, H. (2021). Protective measures against COVID-19 and the business strategies of the retail enterprises: Differences in gender, age, education, and income among shoppers. *Journal of Retailing and Consumer Services, 60*, 102446–102446.

Verma, S., & Gustafsson, A. (2020). Investigating the emerging COVID-19 research trends in the field of business and management: A bibliometric analysis approach. *Journal of Business Research, 118*(June), 253–261.

Winarsih, E., Indriastuti, M., & Fuad, K. (2021). Impact of COVID-19 on digital transformation and sustainability in small and medium enterprises (smes): a conceptual framework. In B. Leonard, P. M. Aneta, & E. Tomoya (Eds.), *AISC advances in intelligent systems and computing* (Vol. 1194, pp. 471–476). Cham: Springer.

Zafar, A., & Mustafa, S. (2017). SMEs and its role in economic and socio-economic development of Pakistan. *International Journal of Academic Research in Accounting, Finance and Management Sciences, 6*, 4.

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