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Article

The effect of digital transformation on the productivity of business enterprises in South Africa

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Abstract: As digital technologies continue to shape the economy, countries are faced with increasing scrutiny in the use of digital transformation to aid productivity and improve performance. In South Africa, the COVID-19 pandemic accelerated Small and medium-sized businesses' (SMEs') uptake of digital technologies, as many businesses had to shift their operations online and adopt new digital tools and technologies to solve the challenges posed by the pandemic. This has led to an increased focus on digital transformation mechanisms among South African firms. Therefore, the study examines the effect of digital transformation on the productivity of firms using cross-sectional data from the World Bank Enterprise Survey (WBES) (2020). The survey was based on firms and is a representative sample of the private sector in the South African economy and covers a wide variety of business environment themes, such as infrastructure, competitiveness, access to finance, and performance indicators. We found that digital transformation improved productivity of South African firms. Furthermore, empirical findings are reassuring robust to the IV-2SLS and quantile regression model, size of business, sectoral and provincial analysis. Finally, we recommend that policy makers should develop and implement initiatives to improve digital infrastructure, including high-speed internet access and reliable connectivity, especially in rural and underserved areas.

Keywords: digital transformation; productivity; SMEs; IV-2SLS; South Africa

1. Introduction

The degree of digital transformation, an emerging disruptive force reshaping the economic landscape and reinvented how organizations operate, drives the business transformation in different nations. Small and medium-sized businesses (SMEs), which are important to and support the global economy, also encourage innovation (Rassool and Dissanayake, 2019). Global attention is being drawn to the advent of digital transformation as a key factor in driving innovation effectiveness and economic growth (Bos-Brouwers, 2010). Nevertheless, despite its potential and resources, South Africa has had difficulties embracing this transformative journey. The nation's slower rate of digital transformation results from various factors, including restricted access to cutting-edge technology, uneven distribution of digital infrastructure, socioeconomic inequality, and regulatory complexity (Manda and Ben Dhaou, 2019). Digitalization is crucial to the expansion of the economy since productivity depends on how widely digital transformation is used in the future.

Exploring the connection between digital transformation and productivity reveals profound implications of the shift in the operational landscape of SMEs within the dynamic context of South Africa (Chingwaru, 2015). In a nation as diverse and yet intricate as South Africa, SMEs operate within a unique ecosystem, offering a range

of ventures spanning from pioneering startups to manufacturing and agricultural endeavours.

According to Mxunyelwa et al. (2017), manufacturing and agricultural sectors account for a sizable share of the nation's Gross Domestic Product (GDP) and employment figures. Despite their apparent importance, they have nevertheless contributed to addressing the problem of unemployment, particularly among young people. There is however, a research gap between productivity and digital transformation, as illustrated in **Figure 1**. Long-term sustainability of digital transformation in SMEs is the gap's focal point. Therefore, this research needs to look at the long-term sustainability and results, which will make it different from other research that concentrated on the acceptance of digital transformation from its early stages.

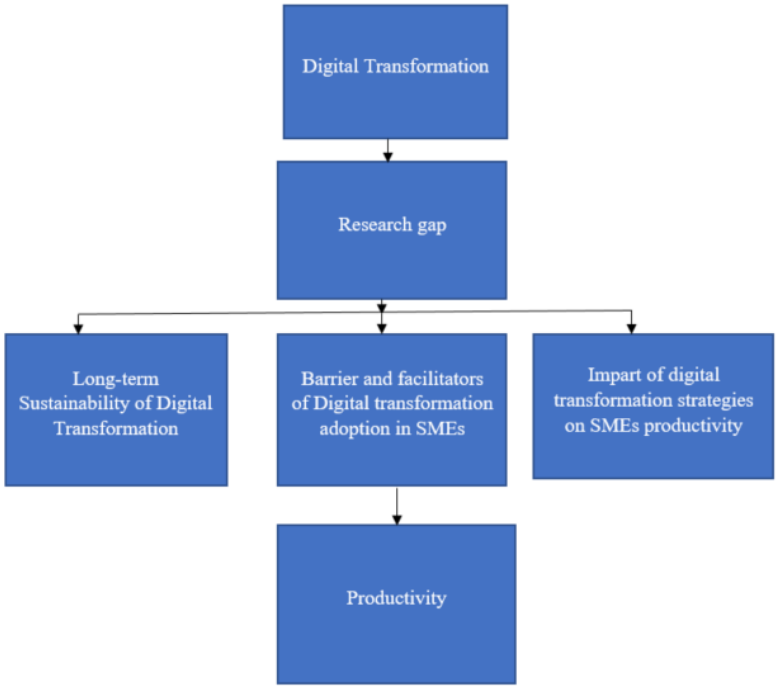

Figure 1. Research gap between productivity and digital transformation.

As a result of the COVID-19 pandemic, South African SMEs rapidly embraced digital technologies to overcome challenges of low patronage due to contact restriction/ social distance requirements. This has led to an increased focus on digital transformation mechanisms among South African firms and underscores a critical shift in business operations, emphasizing the urgency for comprehensive analysis. The forthcoming sections will delve into a detailed exploration of the pandemic's impact on SMEs' digital technology adoption, aligning with our study's focus on understanding the transformative effects of COVID-19 on South African firms (Madondo, 2021)

Foss and Stone (2001) argue that digital transformation has so much promise in increasing productivity, procedures, and opening new markets that may develop SMEs and quickly automate things based on market trends and clients. Additionally, it has potential to enhance the establishment of stronger client relationships. This advantage

becomes crucial in the South African context, with SMES contending with resource limitations and fierce competition. The landscape of SMEs in South Africa encompasses both well established companies and startups, each of this is addressing the district challenges and opportunities (Masutha and Rogerson, 2014). However, there are obstacles confronted in South Africa SMEs, these include misutilization of digital resources and service. The distribution of the benefits that digital transformation promises may be hampered by the level of adoption of digital technology due to lack of available skills (Nabi et al., 2013). This study aims to critically analyse the relationship between SMEs' productivity and digital transformation in South Africa. The goal is to comprehend the level of digital technology adoption by firms and then evaluate how this adoption affects their productivity in South Africa.

2. Review of literature

It is generally acknowledged that digital transformation can stimulate trade and economic growth and reduce disparities between African countries and the rest of the globe (Mabulele, 2020). An organisation's procedures, products, services, and even its underlying business model can all be changed through new technology. Kretzschmar (2021) asserts that digital transformation dissolves the boundaries between businesses and industries, which puts pressure on their ability to compete. Digital transformation is having a positive impact on every industry, which is also having a positive impact on each sector's productivity by removing barriers between people, businesses, and processes through automation. Dilber (2019) indicates that as technology penetrates and permeates almost everything people do, it changes customer, employee, and employer relationships. By removing these barriers, digital transformation enhances and aids in innovating products and service offerings and discovering effective collaboration methods. Regardless of the size or industry, these breakthroughs develop across all enterprises. Akpan et al. (2020) indicate businesses in almost all sectors have recently launched a range of programs to learn more about emerging digital technologies and to use their benefits through the ability to specialise, for instance, or greater adaptability and agility for changing conditions. In the process of digital transformation, these qualities are reflected.

Chatterjee et al. (2021) and Mosupye-Semenya (2022) argued that digital transformation is changing the size, scope, and pace of organisations as well as the composition of the business sectors. While going through a digital transformation phase, businesses seek ways to increase productivity and operational efficiency by utilising technology. The digitalisation of processes is part of the digital transformation, along with productivity improvements and the enhancement of existing physical products with cutting-edge capabilities. In line with the research conducted by Skafi et al. (2020), the digital transformation of business enterprises in South Africa has a significant impact. This transformation influences their capacity to leverage human resources, enhances digital technology security, and safeguards initial project investments. A successful competitive operation necessitates ongoing enhancements in manufacturing processes or service delivery methods, and the digitalization of business processes can affect their competitiveness. Honkanen (2023)

further contends that this digital transformation informs and empowers organizations to adapt to diverse internal and external customer needs by augmenting flexibility.

Process improvement and optimization

According to King et al. (2020), implementing digital transformation can play a pivotal role in enhancing and optimising processes within small and medium-sized manufacturing enterprises (SMEs). This transformation facilitates automation, leading to improved operational efficiency and the attainment of world-class manufacturing standards while reducing dependency on an extensive workforce, which can effectively address labor shortages.

Moreover, as highlighted by Mosupye-Semenya (2022), digital transformation serves as a catalyst for enhancing trend analysis, logistics planning, and inventory management. This is achieved by automating customer management, streamlining data collection and processing, and reducing operational costs while increasing overall revenue and profitability. Furthermore, it has the potential to minimize errors, mitigate risks, and enhance overall performance, thereby enabling suppliers to deliver added value closer to customer operations. In response to the unique challenges posed by the pandemic, the adoption of digital transformation, including innovations like image and speech recognition, has provided SMEs with additional service options and ushered in a significant and ongoing process enhancement.

Balasubramanian (2023) argues that digital transformation could benefit firms and customers by lowering prices, enhancing service quality, coordinating efforts, increasing productivity, and enhancing delivery efficiency. One of the central tenets of digital transformation is that new revenue streams can be created and used to generate value and that digital technologies can help industrial organisations differentiate themselves from rivals by taking on greater responsibility for achieving customer results.

Depaoli and Scornavacca (2020) assert that organsations can concentrate on agile customer co-creation, data-driven payment operation, and scalable ecosystem integration to innovate their business model and expand digital technologies through business model innovation such as mechanism and feedback cycle. According to Eckert et al. (2022), SMEs can use big data as the foundation and digital transformation as the driving force while also developing digital capabilities (like value creation, value delivery, and value capture) to conduct technological Research & Development (R&D) innovation or business model innovation to produce more productive business activities.

3. Methodology

This study leans on cross-sectional data from the World Bank Enterprise survey (WBES) (2020). This survey is based on firms and is a representative sample of the private sector in the South African economy. The survey covers a wide variety of business environment themes, such as infrastructure, competitiveness, access to finance, and performance indicators. In the analysis of this study, we used sales (total annual sales of the establishment in the last fiscal year) divided by (the total number of full-time employees in the establishment) as a gauge for the productivity of the

firms (Output/Labour). Studies like Manda and Ben Dhaou (2019) have used a similar approach to proxy productivity in their empirical paper. The main variable of interest is digital technology adoption or digital transformation. In this study, we adapt the empirical work of Cusolito et al. (2020) by using the firm website as an indicator of digital technology adoption. The variable used is a dummy variable where one indicates that the establishment uses a website in its operation and 0 otherwise. The intuition is that the adoption of digital technology is expected to improve the operations and productivity of the business. This study controlled for other explanatory variables such as firm age, female ownership, managerial experience, research and development, firm innovation, size of businesses, and provincial dummies.

Table 1 presents the summary statistics of the important variables. Productivity ranged from 19.519 and 5.452. The average value of productivity is 12.873, while the standard deviation is 1.93. Similarly, the firm's age ranged from 0.693 and 3.146, with an average of 3.146, and a standard deviation of 0.668. Managerial experience also has an average value of 2.53, with a minimum and maximum value of 0 and 4.094, respectively.

Table 1. Descriptive statistics of the variables.

Variable	Type	Obs	Mean	Std. Dev.	Min	Max
lnpdct	Continuous	1015	12.873	1.928	5.452	19.519
web	Dummy	1097	0.807	0.395	0	1
lnFA	Continuous	1085	3.146	0.668	0.693	5.403
IRC	Dummy	1097	0.069	0.254	0	1
lnME	Continuous	1087	2.53	0.752	0	4.094
RD	Dummy	1097	0.238	0.426	0	1
FO	Dummy	1097	0.377	0.485	0	1

NB: lnpdct (log of firms productivity), web (digital technology adoption), InFA (Log of firm age), IRC (internationally recognize certificate) InMe (Log of managerial experience), RD (Research and development), FO (female ownership)

Model development

Since the nature of our dependent variable is continuous, we adopt simple ordinary least square (OLS) estimation to examine the impact of digital technology adoption and firm productivity. The model is specified thus:

$$Prod = \beta_0 + \beta_1 web_i + \beta_3 X_i + \mu_i \quad (1)$$

where $Prod$ is productivity of the firms, Web_i is a categorical variable which measures digital technology adoption, X_i is a set of control variables which include firm age, female ownership, managerial experience, research and development, firm innovation, size of businesses, and provincial dummies.

However, due to a possible endogeneity bias which may occur due to the following: (1) simultaneity bias, (2) measurement error, and (3) omission of important variables, we employ the instrumental two-stage least squares (IV-2SLS) to address potential endogeneity in the model. In using this IV-2SLS, we need to identify an instrumental variable that is correlated with the endogenous variable $cov(Prod_{i-n}, Z_i) \neq 0$, but not correlated with error term $cov(\mu_{i_i}, Z_i) = 0$.

The two-stage least square estimation is specified thus as:

$$Prod_i = \beta_0 + \beta_1 Web_i + \beta_2 X_i + \tau_t + \mu_i \quad (2)$$

$$Web_i = \emptyset + \alpha_1 Z_i + X_i^* \gamma + \tau_t + v_i \quad (3)$$

The first stage of the instrumental regression is represented in Equation (3), while the second stage is represented in Equation (2). The study used the Durbin-Hausman test to determine endogeneity in this study, and the probability value of the F-test in Equation (3) was employed as an instrument relevance test.

The study finally engaged the Machado and Silva (2019) Method of Moments Quantile Regression (MMQR). This model, contrary to the least-squares regressions produced estimates of the conditional mean of the endogenous variable subject to specific values of the exogenous variables. However, quantile regressions are used to estimate the conditional median or a variety of different quantiles of the response variables. The conditional quantiles' estimation $Q_y(\tau|\mathrm{X})$ takes the following form:

$$Y_{i,t} = \alpha_i + X_{i,t}\beta + (\delta_i + Z_{it}\gamma)U_{i,t} \quad (4)$$

$P\{\delta_i + Z_{it}\gamma\} > 0 = 1.(\alpha, \beta, \delta, \gamma)$ are the parameters to be estimated. $(\alpha_i, \delta_i), i = 1 \ldots, n,$ indicates the individual i fixed effect. Z is a k-vector of identifiable components of X which are differentiable transformations with element l.

4. Findings and discussion

Table 2 displays the impact of digital transformation on the productivity of South African firms using the OLS and IV-2SLS methods. The empirical findings show that the adoption of digital technology improves the productivity of the firms, as this is demonstrated by the positive and significant coefficient of the digital technology variable. We believe digital technology can influence firm productivity due to the following: (1) digital technologies enable firms to automate and optimize their business processes, which reduces manual intervention errors, and ultimately improves the operational efficiency of the firms; (2) it also improves the establishment of new products, business models, and services. These innovative products could open up new revenue streams and increase the firm's market presence, and (3) through the adoption of digital technologies, firms can also maximize their human and material resources efficiently. This study aligns with Kretzschmar's (2021) and Balasubramanian (2023) empirical outcome.

Furthermore, the coefficient of firm age is positive and statistically significant, indicating that the experience of firms matters on productivity. The intuition behind this result is that older firms have more accumulated knowledge, industry-specific knowledge, and expertise. This allows them to make an informed decision and optimize the process and operations. The coefficient of the internationally recognized quality certification variable suggests that establishment that adopts internally known certification are more productive than firms that have not adopted the certification.

The choice of 2020 data was deliberate, because it captures a pivotal period of digital transformation amidst the evolving impact of COVID-19 pandemic. This timeframe aligns with our study's objectives, providing valuable insights into the dynamics of South African firms in response to the pandemic. We commit to a more thorough analysis of SME characteristics, particularly focusing on resource-related

challenges. This enhancement provides a comprehensive understanding of the dynamics impacting SMEs in our study.

We recognize the vital role of capital, human resources, and technology constraints in shaping the digital transformation landscape for SMEs, as highlighted in **Figure 1**. To address this, we meticulously delve into the limitations to provide a nuanced discussion on their interconnected effects and implications for the implementation of digital transformation programs. This expansion offers readers a comprehensive understanding of the intricate challenges faced by SMEs, ensuring a robust exploration of factors that influence the effectiveness of digital initiatives in SMEs sector.

Table 2. Effect of digital transformation on productivity of South African firms.

	(1)	(2)	(3)	(4)
Variables	**OLS**		**IV-2SLS**	
Web	0.288*	0.382***	6.365**	6.033**
	(0.149)	(0.146)	(3.005)	(3.008)
Firm Age	0.307***	0.271***	-	-
	(0.0988)	(0.0938)	-	-
IRC	1.127***	0.937***	1.523***	1.258***
	(0.196)	(0.209)	(0.395)	(0.373)
ME	0.0490	0.0974	1.634***	0.250*
	(0.0920)	(0.0900)	(0.508)	(0.131)
R&D	−0.676***	−0.454***	0.206	−1.205***
	(0.130)	(0.134)	(0.136)	(0.440)
FO	−0.156	−0.123	−0.711**	−0.601*
	(0.124)	(0.120)	(0.338)	(0.315)
Province				
Gauteng	-	0.937***	-	1.430***
	-	(0.192)	-	(0.384)
KwaZulu-Natal	-	−0.0555	-	0.170
	-	(0.219)	-	(0.335)
Western Cape	-	0.0833	-	−0.0969
	-	(0.203)	-	(0.322)
Type of Establishment				
Medium	-	0.0301	-	0.0303
	-	(0.131)	-	(0.215)
Large	-	0.399***	-	*0.334
	-	(0.150)	-	(0.239)
Constant	11.71***	11.07***	7.845***	7.191***
	(0.359)	(0.391)	(2.330)	(2.451)
Observations	1009	1009	1009	1009
R-squared	0.067	0.118	-	-

*** indicates significance at 1%, ** at 5%, and * at 10%; robust standard errors are in brackets.

Managerial experience also has a positive and statistically significant effect on the productivity of South African firms. We believe this may be because experienced managers tend to have a variety of skills and qualities like communication, resource management, and problem-solving. All of these contribute significantly to the productivity of the establishment.

An instrumental regression estimator is used to estimate all regressions. In the instrumental regression, we used firm age as the instrument. ME: managerial experience, IRC: internationally recognized certificate, R&D: research and development, FO: Female ownership, Web: adoption of digital technology.

While innovation and long-term growth depend on research and development (R&D), investment in R&D may be detrimental to the short-term productivity of a firm. This intuition aligns with our empirical analysis, as the coefficient of R&D is negative and statistically significant on productivity. We believe when a significant portion of an establishment's resources is devoted to R&D, it reduces the company's resources for other essential services, affecting performance and productivity. The dummy variable for female ownership is negative and significant, indicating that firms with female ownership are less productive than that of male. Similarly, the result of the provincial dummy indicates that the productivity of firms in Gauteng is more than Eastern Cape by 1.43%. Also, the productivity of KwaZulu-Natal is more than that of the Eastern Cape, although insignificant. However, firms in Western Cape have less productivity than that of Eastern Cape. The results of the type of establishment depict that medium-scale business is more productive than SMEs, as the dummy for medium scale business is positive, though not significant. However, large businesses are more productive than SMEs, given that the coefficient of large business is positive and statistically significant.

4.1. Distributional impact of digital transformation on the productivity of South African firms

In this section, we examined the impact of digital transformation on productivity across different conditional distributions of productivity of South African firms using the Machado and Silva (2019) method. Restricting the interpretation to adoption of digital technology, which is our variable of interest, the empirical outcome presented in **Table 3**, indicates that the adoption of digital technology still has a positive and significant impact on productivity of the firms across the quantiles. The result is in direct similitude with **Table 2**. This suggests that regardless of the distribution of productivity, digital technology adoption increases productivity. However, a close examination of the coefficients suggests that the magnitude of the impact differs across the conditional quantile. For instance, the impact of digital transformation on productivity at the 25th quartile is 0.327%, it increases to 0.386% in 50th quartile, and 0.432% in 75% quartile. The coefficient of location and scale variables are positive, indicating that an increase in the predictor variables leads to an increase in the variability of the response variable at that quantile.

A plausible explanation of this empirical result is that firms with higher initial productivity are likely to have well-established processes and resources. The adoption of digital technology can complement these existing resources, enhancing their

efficiency and effectiveness. Similarly, firms with higher productivity often have larger operations. Hence, digital technology can facilitate the management of larger volumes of data, transactions, and processes, leading to improved productivity gains.

Table 3. Distributional effect of digital transformation on productivity of South African Firms.

	(1)	(2)	(3)	(4)	(5)
Variables	**location**	**scale**	**qtile__25**	**qtile__5**	**qtile__75**
Web	0.382***	0.0659	0.327*	0.386***	0.432***
	(0.144)	(0.0928)	(0.167)	(0.144)	(0.156)
Firm Age	0.271***	0.172***	0.128	0.280***	0.400***
	(0.0950)	(0.0613)	(0.111)	(0.0949)	(0.103)
IRC	0.937***	−0.171	1.080***	0.928***	0.810***
	(0.212)	(0.137)	(0.246)	(0.211)	(0.230)
ME	0.0974	−0.0278	0.121	0.0959	0.0766
	(0.0826)	(0.0533)	(0.0960)	(0.0825)	(0.0896)
R&D	−0.454***	−0.264***	−0.233	−0.467***	−0.651***
	(0.136)	(0.0874)	(0.158)	(0.135)	(0.147)
FO	−0.123	−0.130*	−0.0140	−0.129	−0.220*
	(0.119)	(0.0770)	(0.139)	(0.119)	(0.129)
Province					
Gauteng	0.937***	−0.271**	1.164***	0.923***	0.735***
	(0.194)	(0.125)	(0.226)	(0.194)	(0.211)
KwaZulu-Natal	−0.0555	0.147	−0.178	−0.0481	0.0536
	(0.226)	(0.146)	(0.262)	(0.225)	(0.245)
Western Cape	0.0833	−0.0675	0.140	0.0799	0.0330
	(0.209)	(0.135)	(0.243)	(0.209)	(0.227)
Type of Establishment					
Medium	0.0301	0.175**	−0.116	0.0390	0.160
	(0.132)	(0.0850)	(0.153)	(0.132)	(0.143)
Large	0.399***	0.315***	0.136	0.415***	0.633***
	(0.152)	(0.0984)	(0.178)	(0.152)	(0.166)
Constant	11.07***	0.914***	10.30***	11.11***	11.75***
	(0.366)	(0.236)	(0.427)	(0.367)	(0.398)
Observations	1009	1009	1009	1009	1009

*** indicates significance at 1%, ** at 5%, and * at 10%; robust standard errors are in brackets. ME: managerial experience, IRC: internationally recognized certificate, R&D: research and development, FO: Female ownership, Web: adoption of digital technology.

4.2. Impact of digital transformation on firm productivity: Analysis based on the size of the business

Table 4 presents the analysis on the impact of digital transformation on firm productivity by the size of business. The coefficient of digital technology adoption suggest that small and medium businesses enjoy the benefits of digital transformation more than large corporations. This is validated by the positive signs and significance of small and medium businesses. The justification for this empirical outcome is

because SMEs are more flexible and agile due to their smaller size and simple structure. They can quickly adopt new technology, which could boost their performance and productivity.

Table 4. Analysis by size of business.

	(1)	(2)	(3)
Variables	**Small**	**Medium**	**Large**
web	0.376**	0.428*	0.439
	(0.184)	(0.238)	(0.580)
lnFA	0.123	0.284*	0.462
	(0.115)	(0.160)	(0.364)
IRC	1.514***	0.430	0.694
	(0.414)	(0.360)	(0.588)
lnME	0.289***	−0.178	0.0237
	(0.0994)	(0.132)	(0.338)
RD	−0.334**	−0.757***	0.169
	(0.161)	(0.244)	(0.692)
FO	−0.114	0.0205	−0.383
	(0.143)	(0.201)	(0.538)
Province			
Gauteng	1.275***	0.416	0.626
	(0.218)	(0.329)	(0.772)
KwaZulu-Natal	0.201	−0.698**	−0.0732
	(0.232)	(0.354)	(0.861)
Western Cape	0.192	0.0372	−0.434
	(0.222)	(0.349)	(0.845)
Constant	10.70***	12.29***	11.13***
	(0.437)	(0.662)	(1.571)
Observations	525	351	131
R-squared	0.163	0.117	0.107

*** indicates significance at 1%, ** at 5%, and * at 10%; robust standard errors are in brackets. ME: managerial experience, IRC: internationally recognized certificate, R&D: research and development, FO: Female ownership, Web: adoption of digital technology.

Furthermore, the coefficient of firm age is positive and only statistically significant for medium enterprises only, indicating that the experience of firms matters on productivity for medium enterprises. Similarly, the adoption of internationally recognized quality certification and managerial experience positively impacts small businesses only, and medium and large businesses command insignificant results. The results of managerial experience also differ across the size of business. For instance, the impact is positive for small and large businesses but negative for medium businesses. The adoption of research and development is also negative and significant for small and medium businesses, but positive for large corporation. Similarly, female ownership of establishment is less productive than male in small and large corporation but are productive in medium establishments.

The result of the provincial dummy based on different business sizes depicts that the productivity of firms in Gauteng is more than Eastern Cape (reference category). However, the impact is more pronounced in small businesses than medium and large corporations. Also, the productivity of KwaZulu-Natal is more than Eastern Cape, although insignificant. Nonetheless, medium and large businesses' productivity in KwaZulu-Natal is less than that of Eastern Cape. Similarly, the productivity of small and medium enterprises in the Western Cape is more than that of Eastern Cape, albeit insignificant. However, the productivity of large corporations in western cape is less than eastern cape, since the coefficient is negative.

4.3. Impact of digital transformation on firm productivity: Provincial analysis

We further extended the analysis of this study to provincial level in South Africa (Eastern Cape, Gauteng, KwaZulu-Natal, and Western Cape). The results, presented in **Table 5**, indicate that the adoption of digital technology influences productivity in Eastern Cape, Kwazulu-Natal, and Western Cape. However, the impact is unexpectedly negative in Gauteng. Similarly, firm age, adoption of internationally recognized certificate, positively influence the productivity of the firms across all the provinces. Moreover, managerial experience positively influences firm productivity in Eastern Cape, Western Cape, and KwaZulu-Natal, but its impact is negative in Gauteng. Investing in R&D is negative across all the provinces except for KwaZulu-Natal.

Table 5. Analysis by region (Province).

	(1)	(2)	(3)	(4)
Variables	**EC**	**Gauteng**	**KZN**	**WC**
web	0.949**	−0.00234	0.716*	0.607
	(0.458)	(0.181)	(0.364)	(0.371)
lnFA	0.274	0.238*	0.345	0.316
	(0.262)	(0.128)	(0.218)	(0.199)
IRC	2.671***	0.411	0.477	1.318***
	(0.705)	(0.281)	(0.724)	(0.464)
lnME	0.337	−0.125	0.448*	0.0576
	(0.223)	(0.108)	(0.227)	(0.165)
RD	−0.726*	−0.590**	0.260	−0.663***
	(0.401)	(0.257)	(0.304)	(0.248)
FO	0.0181	0.163	−0.432	−0.389
	(0.349)	(0.172)	(0.291)	(0.240)
Constant	9.770***	12.97***	9.404***	11.04***
	(0.888)	(0.454)	(0.897)	(0.756)
Observations	136	398	219	256
R-squared	0.208	0.050	0.080	0.132

*** indicates significance at 1%, ** at 5%, and * at 10%; robust standard errors are in brackets. ME: managerial experience, IRC: internationally recognized certificate, R&D: research and development, FO: Female ownership, Web: adoption of digital technology.

5. Conclusion and policy implication

The study examined the impact of digital transformation on productivity of South African firms. The study used a cross-sectional data from the World Bank Enterprise survey (2020). In achieving this objective, we used the ordinary least square estimates, IV-2SLS methods, and quantile regressions.

The following are the empirical findings from this study: (1) the adoption of digital transformation positively influences productivity of South African firms. (2) the quantile regression indicates that the adoption of digital technology still has a positive and significant impact on productivity of the firms across the quantiles. However, a close examination of the coefficients suggests that the magnitude of the impact differs across the conditional quantile. For instance, the impact of digital transformation at the 25th quartile is 0.327%, it increases to 0.386% in 50th quartile, and 0.432% in 75% quartile. (3) small and medium businesses enjoy the benefits of digital transformation more than large corporations.

While we acknowledge the complexity of digital transformation, leveraging the business's website is strategic. It serves as a rich, real-world source offering direct insights into digital adoption and its impact on firm productivity.

Given that digital transformation improves productivity of these firms, we recommend that policy makers should develop and implement initiatives to improve digital infrastructure, including high-speed internet access and reliable connectivity, especially in rural and underserved areas. It is also important to encourage public-private partnerships to expand broadband coverage and reduce the digital divide, ensuring that all firms can access digital tools and resources.

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