**THE EFFECTS OF DIGITALIZATION ON TECHNOLOGICAL INNOVATION IN SUB SAHARAN SMEs BY PUTTINT GENDER ON THE AGENDA**

**Abstract**

This study explores the effects of digitalization on innovation in small and medium-sized enterprises, with a focus on gender. Analytically, we use data from a survey conducted by RIA (Research ICT Africa) of 4,410 enterprises in nine sub-Saharan African countries, including Kenya, Mozambique, Nigeria, Ghana, South Africa, Rwanda, Tanzania, Uganda, and Senegal. The survey was conducted in 2018. The linear regression model (OLS) is used to analyze the effect of digitization on technological innovation, and Oaxaca-Blinder econometric model. The main findings reveal that although the adoption of digital tools has a positive impact on innovation, this effect remains limited, reflecting structural challenges such as a lack of infrastructure or digital skills.

# Introduction

Digital transformation is a new phase, often referred to as the fourth industrial revolution, which is profoundly disrupting economic models and their performance (Lorenz et al., 2020). This fourth wave of industrialization, known as Industry 4.0, is characterized by the digitization of production processes through the interconnection of information and communication technologies (ICT) and their integration with production systems (including machines, products, devices, and digital content), thereby enabling autonomous decision-making (Sarbu, 2021). This transition to digital is fueled by the belief that emerging technologies have great potential to foster innovation and strengthen competitive advantage (Solberg et al., 2020).

The digital revolution is redefining the traditional boundaries of businesses, transforming supply chain and value chain systems into integrated value networks. It encourages the creation of new types of networks and gives rise to a veritable ecosystem of digital innovation (Xu, 2020). This ecosystem is characterized by interactions and relationships between organizations and stakeholders, which mobilize digital technologies to design new products and services with high added value (Suseno et al., 2018). It is also a complex network bringing together a variety of social and technological components (Chae, 2019).

This study aims to analyze the effect of digitization on technological innovations in sub-Saharan small and medium-sized enterprises (SMEs), highlighting gender and location disparities. In general, the adoption of digital technologies promotes the development of new skills, knowledge, and abilities, which play an essential role in innovation processes (Ardito et al., 2021).

The analysis focuses on micro, small, and medium-sized enterprises (SMEs). Although these companies often have limited human and financial resources, their lean organizational structure and agility enable them to respond quickly to market developments (Radicic and Pugh, 2017). Nevertheless, SMEs are generally perceived as less innovative (Gallego et al., 2013) and less internationally oriented than large companies (World Trade Organization, 2016).

In an increasingly digital environment, it is becoming essential for SMEs to strengthen their internal digital capabilities in order to keep pace with market transformations, improve their innovation performance, and support their growth (Scoutto et al., 2021). The rise of Industry 4.0, which is based on profound socio-technical changes, requires not only the adoption of new technologies, but also increased investment in human capital, particularly through the promotion of a digital culture among employees (Prodi et al., 2021).

However, unlike men, many women are limited in their ability to invest in technology, and therefore to grow their businesses and compete in the market (Kang, 2022, Odonkor, et al., 2024, Parthiban, et al., 2022). This could be explained by the fact that women entrepreneurs have limited financial knowledge, preventing them from effectively managing their finances, accessing financial services, and making informed financial decisions.

In order to reduce gender bias and discrimination in women's access to technology and financial resources, some countries have implemented gender-specific policies to support women entrepreneurs, particularly in terms of access to finance, training, and technology. For example, the Women's Entrepreneurship Development Program (WEDP) in India provides financial assistance and training to women entrepreneurs. Financial inclusion programs aim to improve women's access to financial services, including savings, credit, and insurance (Abrahams et al., 2024, Aziz et al., 2022, Pal et al., 2022).

These programs often include financial literacy training to help women manage their finances effectively. Some organizations provide women entrepreneurs with access to technology, such as computers, smartphones, and the internet, to help them grow their businesses and access new markets. Governments, development organizations, and the private sector can play a crucial role in supporting women entrepreneurs through targeted interventions and initiatives.

The rest of this study is organized as follows. In the next section, we present a review of the literature on digitalization and technological innovation in SMEs. The following section presents the methodology, explaining the sample, model specification, and empirical strategy. The next section presents the empirical results, followed by the main conclusions, limitations, and ideas for future research.

# Literature review

Women's participation in small and medium-sized enterprises (SMEs) is crucial for economic development and gender equality (Atadoga, et al., 2024; Khan, et al., 2021, Verma, 2019). However, women entrepreneurs often face difficulties in accessing technology, which hinders their ability to grow their businesses and contribute to sustainable development.

The Fourth Industrial Revolution has put pressure on businesses to rethink their current strategies and explore new business opportunities (Rachinger et al., 2019). The development of new products, services, and processes therefore plays a decisive role in the creation, survival, and growth of businesses (Freel, 2010; Neumeyer et al., 2021; Tushman and Nadler, 1986). The way companies use digital technologies is even more decisive for their capacity for innovation and growth (Fitzgerald et al., 2013; Matt et al., 2015; Scoutto et al., 2021).

We have digital tools that can influence the relationship between supply chain partners and customers, for example by involving users and suppliers in product design through digital platforms (Holmström et al., 2017). The implementation of digital technologies can affect any stage of the innovation process, from innovation inputs (such as research and development spending and other investments in innovation) to innovation outputs (e.g., product and process innovations) (Agostini et al., 2020). Digitization promotes the development and acquisition of new skills, competencies, and knowledge, which in turn can lead to new products and processes (Nambisan et al., 2020). Furthermore, absorptive capacity, which is an integral part of firms' innovation processes, depends largely on access to internal and external knowledge.

Thus, if digitization improves access to existing knowledge or provides new knowledge (Agostini et al., 2020), for example through big data analysis, it increases the absorptive capacity of companies and, consequently, the likelihood of new products and processes. However, it should be borne in mind that innovation is not an end in itself; companies innovate to be more profitable, more productive, and more competitive. Similarly, although digital transformation can lead to new products and processes, its ultimate goal is to respond to new demand and explore market opportunities arising from digital technologies (Gobble, 2018; Usai et al., 2021).

Digital transformation can also improve customer service, as it allows large amounts of data to be collected from different sources and used to create strong networks between different partners (Nasiri et al., 2020). By effectively managing interactions with partners and sharing knowledge across organizational boundaries, smart technologies (via, for example, integrated digital platforms) influence the development of supply channel management and customer service (Zhu et al., 2015).

With regard to gender disparity, according to the International Finance Corporation (IFC), women-owned SMEs account for approximately 30% of all registered businesses worldwide (Crane, 2022, Ge, et al., 2022, Odonkor, et al., 2024). However, women entrepreneurs often operate in sectors where productivity and profitability levels are lower than those of their male counterparts. In addition, women face barriers such as limited access to finance, markets, and technology, which limit their ability to grow their businesses and reach their full potential. Women entrepreneurs with limited access to technology, including smartphones, computers, and the internet, are limited in their ability to leverage digital tools for business management, marketing, and access to new markets.

# Methodology

**Data source and sample description**

The data used are from secondary sources. They come from the RIA survey (Research ICT Africa, 2018). Research ICT Africa (RIA) is a pan-African organization that conducts multidisciplinary research on digital governance, policy, and regulation. It contributes to the development of evidence-based and informed policies to improve access to, use of, and application of digital technologies for social and economic development in Africa. Its public interest research on the digital economy and society addresses national, regional, and continental needs. Thus, the survey provides the information and analysis needed to develop flexible and adaptable policies and regulations to cope with an increasingly complex and dynamic digital environment. Research ICT Africa (RIA) contributes to the collection and analysis of data and indicators to establish a knowledge repository to advance research and digital governance. The data used in this research was collected in 2018 from a group of sub-Saharan African countries, including Kenya, Mozambique, Ghana, Nigeria, Rwanda, South Africa, Tanzania, Uganda, and Senegal. The sample consists of 4,409 SMEs ranging in size from 0 to 60 employees. Data was collected in both urban and rural areas (61.8% urban vs. 38.2% rural). Table 1 presents some descriptive statistics on all the variables in the study. There is near parity among managers (49.3% women vs. 50.7% men), but the results vary by sector. The level of education is low (45.6% without formal education, only 10.9% with tertiary education). On the other hand, 15% of managers have vocational training.

**Dependent variable**

Our main dependent variable is innovation capacity. According to Schumpeter, innovation is the introduction of something new into the economic sphere, i.e., the implementation of a new combination of production factors. It goes beyond invention to include the process of producing, marketing, and distributing new products. Schumpeter distinguishes between several types of innovation: products, processes, production methods, markets, and raw materials (OECD, 2005). Based on this definition, we measured innovation through the ability of entrepreneurs to introduce new agricultural or manufacturing products, new marketing methods, and new services. Table 4 shows that among the four forms of innovation considered, commercial innovation is the most widespread (69.2%), followed by services (25.4%). Innovations produced are rare, accounting for less than 12%. Thus, innovation capacity is measured by adding the four forms of innovation. The results reveal that the overall innovation index is low (average = 0.28), suggesting a less innovative ecosystem (Table 1).

**Variable of interest**

Our main variable of interest is digitalization. Digitalization is the process of digitally transforming an organization, process, or economic activity, which involves using digital technologies to improve efficiency, productivity, and competitiveness (...). Digitalization involves the use of technologies such as: computing and information systems, digital networks and communications, data and data analysis, artificial intelligence and machine learning, digital platforms and applications (...). Based on this definition, we have captured digitalization through the use of the internet, mobile phones, and computers in the workplace. Table 1 reveals that there is low adoption of digital tools in companies, notably 8% for the internet, 4.3% for computers, compared to 12% for mobile phones. Our digitization index is constructed by adding the three variables together. The results show that this digitization index is minimal (average = 0.09/1), reflecting a technological lag.

**Control variable**

To control for the effects of digitalization on innovation capacity, several variables are introduced into the model, drawing on the literature on the determinants of innovation adoption in sub-Saharan Africa (Miamo and Pilag, 2022; Chameni and Fomba, 2015). Thus, we take into account manager characteristics such as age, level of education, level of experience, and professional training; company characteristics, particularly its location in a rural or urban area. We also introduce the country to take into account the institutional context and business climate. Table 2 presents the correlation matrix between the different variables in the study.

**Table 1:** Description of variables

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  **Variables** |  Obs |  Mean |  Std. Dev. |  Min |  Max |
| Agricultural product innovation | 4398 | .117 | .321 | 0 | 1 |
| Manufactured product innovation | 4399 | .057 | .232 | 0 | 1 |
| Marketing innovation | 4399 | .692 | .462 | 0 | 1 |
| Service innovation | 4398 | .254 | .435 | 0 | 1 |
| **Innovation\_ index** | **4397** | **.28** | **.099** | **0** | **4** |
| Use of the internet and social media in the workplace | 4399 | .08 | .271 | 0 | 1 |
| Use of mobile phones in the workplace | 2634 | .12 | .325 | 0 | 1 |
| Use of computers (PCs and laptops) in the workplace | 4399 | .043 | .203 | 0 | 3 |
| **Digitalisation\_index** | **2634** | **.09** | **.21** | **0** | **1** |
| Manager gender |  |  |  |  |  |
| Female | 1,570 |  49.28 | .499 | 0 | 1 |
| Male | 1,616 | 50.72 | .499 | 0 | 1 |
| **Manager's level of education** | . | . | . | . | . |
| No education | 2009 | .456 | .498 | 0 | 1 |
| Primary  | 2009 | .368 | .482 | 0 | 1 |
| Secondary  | 2009 | .067 | .25 | 0 | 1 |
| Tertiary  | 2009 | .109 | .311 | 0 | 1 |
| Vocational training  | 2010 | .15 | .357 | 0 | 1 |
| Age of manager | 2009 | 37.565 | 13.071 | 4 | 90 |
| Number of employees in the company  | 4399 | 1.138 | 19.431 | 0 | 60 |
| **Country** | . | . | . | . | . |
| 1. Kenya | 4409 | .095 | .294 | 0 | 1 |
| 2. Mozambique | 4409 | .098 | .297 | 0 | 1 |
| 3. Ghana | 4409 | .113 | .317 | 0 | 1 |
| 4. Nigeria | 4409 | .129 | .335 | 0 | 1 |
| 5. Rwanda | 4409 | .088 | .283 | 0 | 1 |
| 6. South Africa | 4409 | .089 | .284 | 0 | 1 |
| 7. Tanzania | 4409 | .113 | .317 | 0 | 1 |
| 8. Uganda | 4409 | .158 | .365 | 0 | 1 |
| 9. Senegal | 4409 | .117 | .322 | 0 | 1 |
| **Place of residence**  | . | . | . | . | . |
| 0. Rural | 3713 | .382 | .486 | 0 | 1 |
| 1. Urban | 3713 | .618 | .486 | 0 | 1 |
|  |

It appears that the correlation between digitization and innovation is positive but significantly weak (r = 0.089), suggesting that digitization has a limited effect on innovation. This result can be explained by the weak digitization context described by the data above. Furthermore, the correlation between gender and digitization is positive (r = 0.105), suggesting that men use digital tools more than women. We also note that the link between vocational training and innovation is strong (r = 0.125), suggesting that technical training stimulates innovation. However, it should be noted that correlations do not capture net effects or causalities (other uncontrolled variables), hence the specification of the econometric model.

**Table 2:** Correlation analysis

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Variables** | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| (1) Innovation\_index | 1.000 |  |  |  |  |  |  |  |  |
| (2) digitalization\_index | 0.089 | 1.000 |  |  |  |  |  |  |  |
| (3) Gender | 0.030 | 0.105 | 1.000 |  |  |  |  |  |  |
| (4) Education | 0.062 | 0.202 | 0.036 | 1.000 |  |  |  |  |  |
| (5) Professional training | 0.125 | 0.320 | 0.085 | 0.261 | 1.000 |  |  |  |  |
| (6) age of manager | 0.004 | 0.008 | -0.078 | 0.068 | 0.008 | 1.000 |  |  |  |
| (7) number of employees | 0.030 | 0.035 | 0.031 | 0.097 | 0.101 | 0.018 | 1.000 |  |  |
| (8) country | -0.063 | -0.036 | 0.154 | 0.044 | 0.031 | -0.018 | 0.010 | 1.000 |  |
| (9) place of residence | -0.022 | 0.138 | -0.026 | 0.128 | 0.148 | -0.046 | 0.027 | 0.009 | 1.000 |
|  |

 **Specification of the theoretical model**

The objective of this research is to analyze the effects of digitalization on innovation capacity. Knowing all the variables included in our study and how they are constructed, we propose to model the innovation function of companies. Indeed, based on resource-based theory (Penrose, 1959), the innovation capacity of companies depends on several factors, including digitalization. The implementation of digital technologies can affect any stage of the innovation process, from innovation inputs (such as R&D spending and other investments in innovation) to innovation outputs (e.g., product and process innovations) (Agostini et al., 2020). Digitization promotes the development and acquisition of new skills, competencies, and knowledge, which in turn can lead to new products and processes (Nambisan et al., 2020). In addition, absorptive capacity, which is an integral part of business innovation processes, depends largely on access to internal and external knowledge (Miamo and Pilag, 2022). Let us formalize all this with the simplest model reflecting the influence of explanatory variables on an explained variable. Since our innovation variable is an index, a quantitative model is particularly appropriate. This model can be written as follows:

$$Innovation\\_indexe\_{i}=β\_{0}+β\_{1}Digitalisation\\_index\_{i}+β\_{3}X\_{i}+ε\_{i}$$

Where 〖Innovation\_index〗\_i represents the innovation index, 〖Digitalisation\_index〗\_i represents the digitalisation index, and ε\_i is the error term that follows a normal distribution. X\_i is the vector of control variables. The estimation technique used is ordinary least squares (OLS). However, since we consider that digitalization could have a differentiated effect on technological innovation capacity depending on whether one is a woman or a man, it is important to continue our analysis with the Oaxaca-Blinder decomposition. The Oaxaca-Blinder decomposition model is a statistical method used to analyze differences in outcomes between two groups, such as wages between men and women. It decomposes the total gap into two components: one part due to differences in observable characteristics between the groups (composition effect) and one part due to differences in regression coefficients (influence effect). In the context of our study, the Oaxaca-Blinder decomposition could reveal a gap in access to digital technologies (internet, smartphones, computers) between women and men, and that part of this gap could be explained by differences in observable characteristics, such as level of education and professional training.

# Results and interpretation

**Basic regression**

Table 3 presents three linear regression models (OLS) analyzing the effect of digitization on technological innovation, with progressive controls. The first column of Table 3 shows a univariate model. It appears that a one-unit increase in the digitization index is associated with a 0.034 point increase in the innovation index, all other things being equal. This result is consistent with that of Brynjolfsson and McAfee (2014), showing that digitization (cloud, AI, collaborative tools) improves innovation in SMEs in developing countries, with a more pronounced effect in manufacturing sectors. Other studies show that, in sub-Saharan Africa, internet adoption increases the probability of innovation in rural SMEs by 15%. However, this model does not control for other factors (potentially overestimating the effect). The second column takes into account the characteristics of the manager, including gender, age, level of education, and professional training. It appears that professional training has a significant positive influence on innovation capacity. Similarly, the results show that gender has a significant but negative influence on innovation capacity. This result is similar to that of Aterido et al. (2019), showing that women-led businesses in Africa innovate 20% less than those led by men, even after controlling for education and size.

**Table 3:** Basic regression

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) |
| **VARIABLES** | Innovation\_index1 | Innovation\_index1 | Innovation\_index1 | Innovation\_index1 |
|  |  |  |  |  |
| Digitalization\_  | 0.0341\*\*\* | 0.0196\*\* | 0.0156\* | -0.239\*\*\* |
|  | (0.00741) | (0.00788) | (0.00816) | (0.0169) |
| Gender (female) |  | -0.00684\*\* | -0.00710\*\* | -0.00684\*\*\* |
|  |  | (0.00284) | (0.00289) | (0.00262) |
| Age |  | 3.87e-05 | 4.68e-05 | 3.97e-05 |
|  |  | (0.000106) | (0.000106) | (9.59e-05) |
| Education |  | 0.00129 | 0.00103 | -8.27e-06 |
|  |  |  |  | (0.00134) |
| DigitalizationXformation |  |  |  | 0.0153\*\*\* |
|  |  | (0.00146) | (0.00148) | (0.00392) |
| Professional training |  | 0.0179\*\*\* | 0.0175\*\*\* | 0.744\*\*\* |
|  |  | (0.00430) | (0.00432) | (0.0443) |
| Company size |  |  | 0.00110\* | 0.00142\*\* |
|  |  |  | (0.000639) | (0.000580) |
| Residence stratum  |  |  | -0.000186 | -0.000808 |
|  |  |  | (0.000669) | (0.000608) |
| Country  |  |  | 0.00314 | 0.00109 |
|  |  |  | (0.00308) | (0.00280) |
| Constant | 0.268\*\*\* | 0.256\*\*\* | 0.255\*\*\* | 0.261\*\*\* |
|  | (0.00169) | (0.00480) | (0.00651) | (0.00592) |
|  |  |  |  |  |
| Observations | 2,633 | 1,311 | 1,311 | 1,311 |
| R-squared | 0.008 | 0.035 | 0.038 | 0.038 |

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Column 3 of the table takes into account not only the characteristics of the manager, but also those of the company, such as size, measured by the number of employees, location, and institutional characteristics. Column 4 takes into account the interaction between training and digitization. It appears that taking this variable into account boosts innovation, but with a negative effect. This change in sign implies that technical training is the main channel through which digitization influences the innovation process in companies. Also, despite taking into account the characteristics of the manager and the company, the uneven effect of digitization on innovation capacity persists. Hence the importance of Oaxaca's decomposition to identify the sources of inequality.

**Decomposition of the effect of digitalization on innovation by gender**

Table 4 presents a decomposition of the innovation gap between companies led by men and women, isolating the contributions of digitalization and other factors. First, the results indicate that there is a difference in innovation between male-led and female-led firms and that this gap is significant at the 1% level. This result implies that, compared to male-led firms, female-led firms have an innovation index that is 0.007 points lower on average (Table 4; column 1). Almost 29% of this gap can be explained by observable differences (education, digitalization, training, etc.). Meanwhile, 71% of the unexplained part of the gap is due to unobserved factors (discrimination, cultural biases, etc.). This result is consistent with that of Aterido et al. (2019) on African SMEs, which also found a high unexplained portion (60-70%) attributed to discriminatory social norms, and contrasts with that of Marlow and McAdam (2013), which shows that in European tech ecosystems, the unexplained portion is almost zero (neutral effects after controls).

**Table 4:** Oaxaca-Blinder decomposition by gender

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) |
| **VARIABLES** | Effet total  | Expliqué  | Non expliqué  | Interaction |
|  |  |  |  |  |
| Digitalization\_ |  | -0.000898\* | -0.000745 | 0.000368 |
|  |  | (0.000574) | (0.00165) | (0.000819) |
| Age |  | 0.000289 | -0.00812 | -0.000475 |
|  |  | (0.000364) | (0.00750) | (0.000469) |
| Education |  | 4.62e-06\* | 0.00473 | -2.45e-05 |
|  |  | (3.81e-05) | (0.00544) | (0.000157) |
| Professional Training |  | -0.00101\*\* | 0.000691 | -0.000241 |
|  |  | (0.000495) | (0.00150) | (0.000530) |
| Company Size |  | -0.000727 | -0.00222\* | 0.00158 |
|  |  | (0.000507) | (0.00231) | (0.00165) |
| Residential Stratum |  | -7.16e-05 | -0.00184\* | 0.000287 |
|  |  | (0.000915) | (0.00716) | (0.00112) |
| Country |  | 0.000281 | -0.000403 | -5.30e-05 |
|  |  | (0.000388) | (0.00373) | (0.000491) |
| Group 1 (Female) | 0.257\*\*\* |  |  |  |
|  | (0.00171) |  |  |  |
| Group 2 (Male) | 0.264\*\*\* |  |  |  |
|  | (0.00217) |  |  |  |
| Total Difference | -0.00735\*\*\* |  |  |  |
|  | (0.00276) |  |  |  |
| Explained Party | -0.00213\* |  |  |  |
|  | (0.00136) |  |  |  |
| Unexplained Party | -0.00666\*\* |  |  |  |
|  | (0.00314) |  |  |  |
| Interaction | 0.00144 |  |  |  |
|  | (0.00203) |  |  |  |
| Constant |  |  | 0.00125 |  |
|  |  |  | (0.0124) |  |
| Observations |  |  |  |  |
| Digitalization\_ | 1,311 | 1,311 | 1,311 | 1,311 |

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

The breakdown by variable reveals that digitalization has a non-significant effect on the explained part, which implies that women do not have significantly lower access to digital tools compared to men. Also, the unexplained part is non-significant), which means that there is no discrimination in the use of tools. On the other hand, regarding the size of the company, the explained part is significant, which implies that companies run by women are smaller, which reduces their capacity to innovate. Regarding location, the explained part is significant, implying that women more often run companies in rural areas, less conducive to innovation. All things considered, one of the major implications is that there are structural inequalities in technological innovation between men and women. The gap is mainly due to unobserved factors (71%), suggesting systemic barriers, particularly in terms of unequal access to financial networks and gender stereotypes in innovative sectors. Contrary to expectations, digitalization does not significantly contribute to widening the innovation capacity gap, but rather to narrowing it. This may indicate that digital tools are equally inaccessible to men and women in this context. Consequently, policies to improve access to digital tools must be implemented in the sample countries. Furthermore, their impact on innovation is weak without complementary skills. Consequently, technological capacity building and continuing education policies must be implemented in the sample countries to boost the effect of digitalization in reducing innovation skills gaps. Policies aimed at closing gaps in firm size (access to credit for women) must also be implemented, as well as interventions to reduce unobserved biases (mentoring, gender-based professional networks).

# Conclusion and Recommendations

This study explores the impact of digitalization on technological innovation in Sub-Saharan SMEs, highlighting disparities related to gender and location. The results reveal several key lessons:

**Modest but significant impact of digitalization:**

Although the adoption of digital tools has a positive impact on innovation, this effect remains limited, reflecting structural challenges such as a lack of infrastructure or digital skills. Public policies must therefore go beyond simple access to technologies to include appropriate training and technical support.

**Persistent gender inequalities:**

The Oaxaca-Blinder decomposition shows that 71% of the innovation gap between men and women is unexplained by observable variables, suggesting systemic barriers (discrimination, unequal access to financial networks, social norms). These results call for targeted interventions:

- Mentoring programs for women entrepreneurs;

- Preferential credit for women-led SMEs;

- Awareness raising about gender bias in innovation ecosystems.

**Rural vs. urban challenges:**

Rural businesses innovate less due to limited access to resources (digitalization, education). However, digitalization plays a marginal role in this gap, highlighting the importance of combining digital infrastructure and local development (electricity, transportation).

**Limitations and Future Directions:**

The study is based on cross-sectional data (2018), limiting causal analysis. Longitudinal data would allow for a better understanding of temporal dynamics. The absence of variables such as access to finance or business culture potentially biases the results. Qualitative research could shed light on the mechanisms underlying the "unexplained" gaps.

**Strategic Recommendations**

*For governments:*

- Invest in rural innovation hubs that combine digital access and training;

- Establish gender quotas in tech entrepreneurship support programs.

*For international organizations:*

- Fund longitudinal surveys to monitor the evolution of disparities;

- Support pilot projects testing the impact of gender-based digital training.

*For researchers:*

- Deepen the analysis of the interactions between digitalization and managerial skills.

- Study the role of informal networks (family, community) in innovation.

This research confirms that digitalization alone is not enough to transform innovation in sub-Saharan Africa. A holistic approach, integrating gender equity, technical education, and inclusive infrastructure, is essential to unlock the potential of SMEs. As Aterido et al. (2019) point out, "inclusive innovation requires combating invisible biases as well as digital divides." Nevertheless, recent advances in mobile connectivity and STEM education suggest opportunities for catching up, provided policies are targeted and measured.

**Bibliographic references**

Agostini, L., Galati, F., Gastaldi, L., 2020. The digitalization of the innovation process. Challenges and opportunities from a management perspective. Eur. J. Innov. Manag. 23 (1), 1–12.

Ardito, L., Raby, S., Albino, V., Bertoldi, B., 2021. The duality of digital and environmental orientations in the context of SMEs: implications for innovation performance. J. Bus. Res. 123, 44–56.

Chae, B., 2019. A general framework for studying the evolution of the digital innovation ecosystem: the case of big data. Int. J. Inf. Manag. 45, 83–94.

Chameni Nembua, C., and B. Fomba Kamga. 2015. “Rapport général de l’étude sur les déterminants de la performance des entreprises en Afrique subsaharienne francophone: cas du Cameroun, de la Cote d’Ivoire et du Sénégal; rapport du Cameroun.” Study report is available online at the following address: https://idl-bnc-idrc.dspacedirect.org/ handle/10625/54333.

Fitzgerald, M., Kruschwitz, N., Bonnet, D., Welch, M., 2013. Embracing digital technology. A new strategic imperative. In: MIT Sloan Management Review. Research Report.

Freel, M., 2010. External linkages and product innovation in small manufacturing firms. Entrep. Reg. Dev. 12 (3), 245–266.

Gallego, J., Rubalcaba, L., Hipp, C., 2013. Organizational innovation in small European f irms: a multidimensional approach. Int. Small Bus. J. 31 (5), 563–579.

Gobble, M.M., 2018. Digitalization, digitization, and innovation. Res.-Technol. Manag. 61 (4), 56–59.

Holmstr¨ om, J., Liotta, G., Chaudhuri, A., 2017. Sustainability outcomes through direct digital manufacturing-based operational practices: a design theory approach. J. Clean. Prod. 167, 951–961.

Lorenz, R., Benninghaus, C., Friedli, T., Netland, T.H., 2020. Digitization of manufacturing: the role of external search. Int. J. Oper. Prod. Manag. 40 (7/8), 1129–1152.

Matt, C., Hess, T., Benlian, A., 2015. Digital transformation strategies. Bus. Inform. Syst. Eng. 57, 339–343.

Nambisan, S., Lyytinen, K., Yoo, Y., 2020. Handbook of Digital Innovation. Edward Elgar Publishing.

Nasiri, M., Ukko, J., Saunila, M., Rantala, T., 2020. Managing the digital supply chain: the role of smart technologies. Technovation 96–97, 102121.

Neumeyer, X., Santos, S.C., Morris, M.H., 2021. Overcoming barriers to technology adoption when fostering entrepreneurship among the poor: the role of technology and digital literacy. IEEE Trans. Eng. Manag. 68 (6), 1605–1618.

Prodi, E., Tassinari, M., Ferrannini, A., Rubini, L., 2021. Industry 4.0 policy from a sociotechnical perspective: the case of German competence centres. Technol. Soc. Chang. 175, 121341.

Rachinger, M., Rauter, R., Müller, C., Vorraber, W., Schirgi, E., 2019. Digitalization and its influence on business model innovation. J. Manuf. Technol. Manag. 30 (8), 1143–1160.

Radicic, D., Pugh, G., 2017. Performance effects of external search strategies in European small and medium-sized enterprises. J. Small Bus. Manag. 55 (S1), 76–114.

Sarbu, M., 2021. The impact of industry 4.0 on innovation performance: insights from German manufacturing and service firms. Technovation.

Scoutto, V., Nicotra, M., Del Giudice, M., Krueger, N., Gregori, G.L., 2021. A microfoundational perspective on SMEs'growth in the digital transformation era. J. Bus. Res. 129 (C), 382–392.

Scoutto, V., Nicotra, M., Del Giudice, M., Krueger, N., Gregori, G.L., 2021. A microfoundational perspective on SMEs'growth in the digital transformation era. J. Bus. Res. 129 (C), 382–392.

Suseno, Y., Laurell, C., Sick, N., 2018. Assessing value creation in digital innovation ecosystems: a social media analytics approach. J. Strateg. Inf. Syst. 27 (4), 335–349.

Tushman, M., Nadler, D., 1986. Organizing for innovation. Calif. Manag. Rev. 28 (3), 74–92.

Usai, A., Fiano, F., Messeni Petruzzelli, A., Paoloni, P., Farina Briamonte, M., Orlando, B., 2021. Unveiling the impact of the adoption of digital technologies on f irms'innovation performance. J. Bus. Res. 133, 327–336.

Wendji, C. M., & Pilag Kakeu, C. B. (2022). The effect of external knowledge on innovation capacity of SMES: Does the source of knowledge matter?. *African Journal of Science, Technology, Innovation and Development*, *14*(6), 1655-1666.

Xu, Y., 2020. Digital innovation ecosystem: research context, research hotspot and research trends-knowledge mapping analysis using citespace. J. Electr. Inform. Sci. 5, 72–80.

Zhu, Z., Zhao, J., Tang, X., Zhang, Y., 2015. Leveraging e-business process for business value: a layered structure perspective. Inf. Manag. 52 (6), 679–691.