

"The Economic Implications of Digital Transformation and Cybersecurity on Growth Dynamics in Emerging African Economies: A Panel Data Analysis"

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Abstract: This study investigates the impact of digital transformation, cybersecurity, physical capital, and unemployment on economic growth in selected African economies (Algeria, Tunisia, Morocco, Libya, Egypt, South Africa, Gabon, Botswana, and Mauritius) using panel data analysis. Covariance and correlation matrices reveal a negative relationship between economic growth (LGDP) and the variables of physical capital (LK), unemployment (LUN), digital transformation (LDT), and cybersecurity (LNCSI). These results suggest a structural shift where resources are reallocated from traditional physical capital toward human capital and digital sectors, indicating a broader transition toward technology-driven economies. Investment in cybersecurity is positively correlated with digital transformation, highlighting the necessity of cybersecurity spending alongside digital progress. The observed countercyclical relationship between economic growth and unemployment aligns with Okun's Law, though structural unemployment persists due to skills mismatches. The findings underscore the need for policies that support sustainable digital and cybersecurity investments while addressing short-term growth trade-offs. Recommendations are provided to guide African policymakers in fostering inclusive and resilient digital economies.

Key words: digital transformation, cybersecurity, economic growth, Emerging African Economies, panel data analysis.

I. Introduction

In the contemporary digital era, economic growth, innovation, digital transformation, and cybersecurity are deeply intertwined. Digital transformation, digital innovation, and digital development are recognized as pivotal drivers of productivity, competitiveness, and sustainable economic growth. However, cybersecurity remains a critical challenge, ensuring the resilience and long-term stability of digitalized economies (Yudong & Xi Chu, 2022; Ashish et al., 2024).

In emerging African economies, the simultaneous pursuit of digitalization and cybersecurity is crucial to promote inclusive growth, safeguard digital infrastructure, and prevent economic disruption caused by cyber threats. Understanding this relationship provides insights for designing policies that align technological adoption with sustainable economic development.

II. Literature review

Digital Transformation and Economic Growth

Digital transformation enhances productivity and creates employment opportunities, contributing positively to economic growth (Inna et al., 2021). Digital innovation strengthens competitiveness through new products and services, benefiting technologically advanced nations more than less developed ones (László, 2024).

Digital development, defined as the expansion of digital infrastructure and ICT accessibility, plays a significant role in economic growth. In the EU, policies promoting innovation, digital infrastructure, and reduced regional disparities have been critical in achieving inclusive and sustainable growth (László, 2024). Similarly, Lukmanova Inessa et al. (2023) and Yudong & Xi Chu (2022) note that digitization improves efficiency, stimulates innovation, and strengthens macroeconomic stability.

Cybersecurity in the Digital Economy

The expansion of digital infrastructure increases exposure to cyber threats. Cybersecurity is essential for protecting economic stability and ensuring sustainable growth (Vasiu & Vasiu, 2018; Saqib et al., 2023). Cyber threats such as ransomware and phishing are becoming increasingly sophisticated, while integration of technologies like IoT and cloud solutions introduces additional vulnerabilities (Lesmana Desta et al., 2023).

Investing in cybersecurity not only safeguards digital assets but also supports confidence in digital systems, which is critical for the success of digital transformation initiatives (Ashish et al., 2024).

African Context

Recent studies indicate that digital adoption in Africa is accelerating, particularly in countries like Morocco, Tunisia, South Africa, and Mauritius. However, a gap remains between digital development and cybersecurity preparedness in countries such as

Egypt and Botswana, increasing vulnerability to cyber threats. Sectoral analysis highlights that finance, telecommunications, and e-government services are most affected, emphasizing the need for sector-specific cybersecurity strategies.

Table 1: challenges and treats of cybersecurity

Challenges Threats	Methods	Tools	Description
Challenges	Challenges of Digital Transformation	Increased Complexity	Digital transformation complicates IT systems, making security management more difficult.
		Technology Integration:	New technologies, such as IoT and cloud solutions, introduce new vulnerabilities that require constant security updates.
Threats	Cybersecurity Threats	Sophisticated Cyberattacks	Cyberattacks are evolving, with increasing sophistication in methods like ransomware and phishing.
		System Vulnerabilities	Complex systems can have exploitable weaknesses that cybercriminals target.

Source : Lesmana Desta et al. (2023)

III. Data and Methodology

Data Sources and Sample Selection

Data were collected from multiple sources, including the National Cybersecurity Index (NCSI) and Digital Development Level (DDL), for ten African countries with significant ICT investments: Libya, Morocco, Seychelles, Mauritius, South Africa, Algeria, Botswana, Tunisia, Egypt, and Gabon. The sample selection was guided by ICT infrastructure levels, digital readiness, and data availability to ensure reliable cross-country comparison.

Variable Justification

- **LGDP:** Log of real GDP, representing economic growth.
- **LK:** Log of physical capital, capturing traditional investment levels.
- **LUN:** Log of unemployment rate, reflecting labor market conditions.
- **LDT:** Log of digital transformation index, representing digital adoption.
- **LNCISI:** Log of cybersecurity index, capturing the strength of national cybersecurity frameworks.

Methodology

Panel data analysis was employed, using covariance and correlation matrices to assess relationships between variables. Unit root tests (ADF, PP-Fisher Chi-square) ensured stationarity, and first differencing was applied where necessary. Covariance analysis highlights the direction and strength of linear relationships, while correlation coefficients provide standardized measures of association between variables.

The following table presents a relevant study on the relationship between digital transformation and the economic growth. The selecting the studies (A. Ş. Chenic et al., 2023; A. Stavtyskyy et al., 2019; D. Esses et al., 2021; D. K. Nguyen et al., 2023; J. Yang et al., 2023; M. Olczyk and M. Kuc-Czarnecka, 2022; Y. Luo et al., 2023; Y. Peng and C. Tao, 2022) including many regions and country groups in the sample was also important.

Table 2 : Relationship between digital transformation and economic growth

Author(s)	Period	Countries	Variables	Method	Results
(A. Ş. Chenic et al., 2023)	2014-2019	European countries	GDP, Labor productivity, export	Linear regression	A strong relationship between digitalization and productivity and GPD, a weak relationship between digitalisation and experts

(J. Yang et al., 2023)	2013-2020	29 Companies from provinces in China	Panel data of listed companies	Transaction cost theory and geoeconomics	A strong positive U -shaped relationship between digital transformation and corporate sustainability
(D. Esses et al., 2021)	2015-2020	Visegrad 4 countries	DESI index and SDG goals	Country ranking based on indicators, comparison with EU average values	GDP in this research correlates strongly with SDG targets.
(A. Stavitsky et al., 2019)	2013-2018	28 European countries	Consumption index, unemployment, DESI elements	Panel regression	1% increase in the consumption index results in an approximately 0.2% increase in DESI and a 1 % increase in unemployment results in a decrease of approximately 0.2 DESI.
(M. Olczyk and M. Kuc-Czarnecka, 2022)	2015-2020	European Union	Element of DESI index	Sensitivity based analysis	Connectivity has the greatest impact on digital transformation. DESI is a significant regressor in the change in GDP.
(N. Chena, et al., 2022)	2007-2019	3778 listed companies in China	Workshare Digital Economy Technological progress output flexibility	2ways fixed effect model	There is a digital divide in the effects of changes in factors, skewed and returns to scale of heterogeneous industries
(D. K. Nguyen et al., 2023)	2019	206 Dutch companies	Digital proactivit, motivation, organizational flexibility	OLS regression, complementary analysis	Digital proactivity, commitment to change, and organizational flexibility all contribute to digital transformation.
(Y. Luo et al., 2023)	2013-2020	All Chinese A-share companies	Factors in the development of digital transformation	Multivariate regression analysis	A better business environment significantly improves the company's digital transformation; by involving senior managers and increasing digital input, it attracts more state support related to digitalization
(Y. Peng and C. Tao, 2022)	2012-2020	1578 Chinese listed companies	GPM, CER,ROA,ROE and other variables	Lag regression analysis, general momentum estimation	According to digital public policy, innovation performance is the main driving force for improving corporate performance.

Source: (László, 2024)

The comprehensive collection of data from multiple sources forms the foundation of this study. Initially, we examined the trends in the Digital Development Index and the Cybersecurity Index.

Subsequently, we estimated the impact of digital development strategies on sustainable economic growth. The Digital Development Index is measured by the Digital Development Level (DDL), while the Cybersecurity Index is assessed using the National Cybersecurity Index (NCSI).

Our analysis focuses on the top ten African countries with significant investments in ICT. These include Libya (88.1 points), Morocco (86.8 points), Seychelles (84.7 points), Mauritius (84.2 points), South Africa (83.6 points), Algeria (80.9 points), Botswana (78.7 points), Tunisia (77.2 points), Egypt (76.8 points), and Gabon (74.7 points).

IV. Results

The results show that Marrocco, Tunisia and Libya have a coherent tendency between NCSI and DDL with a positive difference. In the first hand, the positive difference underlined into variables means that the development of cybersecurity in the present countries is in line with digital development. Moreover, an investment on Cybersecurity strategy protects country against attacks like confidentiality breach, accidents like denial of e services and criminality like data integrity breach.

In the other hand, the negative result showed in the table concludes that the digital society in the country like Egypt and Botswana (-0,68, -5,50) is more developed than the scope of national cybersecurity. In fact, the cyber-risks affect the normal functionality of the national information and communication systems and electronic services.

The following table presents the difference between the NCSI and the DDL.

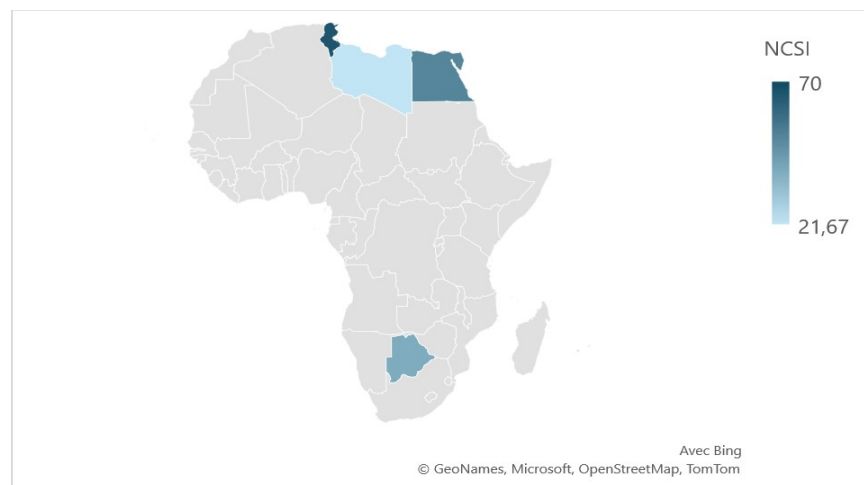
Table 3: Difference between NCSI and DDL (2016-2023)

Nbr	Country	NCSI	DDL	Difference
01	Egypte	50,83	51,51	-0,68
02	Marroco	70	25,29	+17,71
03	Tunisia	65,83	53,78	+12,05
04	Botswana	39,17	44,67	-5,50
05	Libya	21,67	16,88	+4,79

Source: <https://ncsi.ega.ee/ncsi-index/>

To manage the cited cyber threats, each country has a negative gap must strength the capacity building to get a strategic, preventive and responsive cyber security as shown Fig.1.

Fig.1: Digital development strategy



Five countries in the survey of NSCI 2016-2023 such (Gabon, Algeria, Seychelles, South Africa and Mauritius) are absents because no information about NCS Index is unavailable.

Unit Root and Stationarity

Unit root tests confirmed that LK, LUN, and LNCSI required first differencing to achieve stationarity at the 5% significance level. LGDP and LDT were stationary at level.

Table 4: Unit root test

Variables	Probability (Individual intercept)	
	At level	At the first difference
LGDP	0.0170*	
	0.5406**	
	0.5520***	
LK	0.2230*	0.0000*
	0.6227**	0.0009**
	0.6868 ***	0.0003***
LUN	0.3049*	0.0000*

	0.1737**	0.0009**
	0.6582***	0.0003***
LDT	0.0000*	
	0.3932**	
	0.4941***	
LNCS	0.8944*	0.0000*
	0.9986**	0.0229**
	0.9744***	0.0263***

Source: EViews output (author's calculation)

Covariance and Correlation Analysis

Covariance analysis indicates a negative relationship between LGDP and LK, LUN, LDT, and LNCSI, suggesting that economic growth coincides with a reallocation of resources from physical capital to human capital and digital sectors. Positive covariance between LDT and LNCSI (0.626) indicates that cybersecurity investment grows alongside digital transformation.

Table 5: Covariance analyses

Variables	LGDP	LK	LUN	LDT	LNCSI
LGDP	0.112572	-0.068497	-0.009076	-0.034865	-0.135986
LK	-0.068497	0.702255	0.003498	-0.003191	-0.123152
LUN	-0.009076	0.003498	0.030643	-0.005152	0.019152
LDT	-0.034865	-0.003191	-0.005152	0.047886	0.132364
LNCSI	-0.135986	-0.123152	0.019152	0.132364	0.931049

Source : EViews output (author's calculation)

Correlation analysis reinforces these findings: LGDP is negatively correlated with LK (-0.244), LUN (-0.155), LDT (-0.475), and LNCSI (-0.420), reflecting transitional dynamics where rapid growth requires structural adjustments in labor, investment, and cybersecurity priorities.

Table 6: Correlation variable study

Variable s	LGDP	LK	LUN	LDT	LNCSI
LGDP	1.000000	-0.243619	-0.154526	-0.474859	-0.420043
LK	-0.243619	1.000000	0.023846	-0.017400	-0.152302
LUN	-0.154526	0.023846	1.000000	-0.134499	0.113384
LDT	-0.474859	-0.017400	-0.134499	1.000000	0.626869
LNCSI	-0.420043	-0.152302	0.113384	0.626869	1.000000

Source: E-views output (Author's calculation)

Sectoral and Country-Specific Insights

- **Morocco, Tunisia, Libya:** Positive difference between NCSI and DDL indicates coherent alignment of digital development and cybersecurity.
- **Egypt, Botswana:** Negative difference suggests cybersecurity lags behind digital adoption, exposing vulnerabilities in critical sectors such as finance and government services.

V. Discussion

The negative correlation between economic growth and investment in physical capital, digital transformation, and cybersecurity reflects the short-term costs of transitioning to a technology-driven economy. Structural unemployment arises from skill mismatches, while high investment costs in cybersecurity and digital infrastructure limit immediate growth benefits.

These findings emphasize the need for African policymakers to design strategies that align digital transformation with workforce development and cybersecurity investment, mitigating risks while fostering long-term growth.

VI. Conclusion

This study highlights a complex transition in emerging African economies, where economic growth is accompanied by structural adjustments in investment, labor, and cybersecurity. While digital transformation presents opportunities for long-term growth, short-term costs, skills gaps, and cybersecurity vulnerabilities pose significant challenges.

Policymakers must adopt comprehensive, sector-specific strategies that integrate human capital development, robust cybersecurity, and digital infrastructure expansion to achieve sustainable and inclusive growth.

Limitations

This study is limited to selected African countries which may reduce the generalizability of the findings. The analysis focused mainly on short-term economic effects without fully exploring long-term dynamics.

Additionally, sectoral insights were preliminary and require more detailed industry-level studies to better understand the impact of digital transformation and cybersecurity on specific economic activities.

Policy Recommendations

To foster sustainable digital growth in Africa, it is essential to prioritize strategic investment in human capital by developing targeted digital skills programs, vocational training, and continuous upskilling to bridge workforce gaps in high-tech sectors, while simultaneously establishing robust cybersecurity frameworks through national strategies, sector-specific risk assessments, and public-private partnerships for threat mitigation.

Equally important is the expansion of digital infrastructure, with investments in high-speed networks, cloud platforms, and e-government services to promote inclusive digitalization, complemented by sector-specific strategies that tailor policies to the digital maturity and cybersecurity needs of critical industries such as finance, telecommunications, and e-government.

Strengthening data collection and monitoring systems to better evaluate the long-term impact of digital transformation and cybersecurity initiatives will enhance evidence-based policymaking, while policy harmonization across digital, cybersecurity, and economic domains can maximize efficiency and growth potential. Finally, fostering regional collaboration through knowledge-sharing and cooperative mechanisms among African countries will help mitigate cybersecurity threats and accelerate the development of integrated regional digital markets.

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