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The Digital Economy and an Overview of the South African Economy

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ABSTRACT

In recent decades, the digital economy has become a central force in reshaping global economic structures. Understanding its impact is especially critical for emerging economies striving for sustainable development.

The effects of digitalization on the global economy are being felt across all sectors...The effects of digitalization on the global economy are being felt across all sectors. It is evident that it will lead to a reshaping of employment, inflation, financial markets, production, consumption, health, trade, aviation, and tourism sectors. Within the context of digitalization, key developments such as the growth of e-commerce, the expansion of the logistics sector, the proliferation of digital financial instruments, and the digitalization of economic activities will be examined to assess the impact of digital transformation on economies. This study focuses on empirically analyzing the effects of digitalization on the economic dynamics of South Africa. Econometric analysis methods will be employed using data sets covering the period from 2000 to 2024.

Keywords: Digitalization, Globalization, South African Economy

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1. Introduction

The phenomenon of digitalization generally focuses on the renewal of business processes in production, aiming to increase productivity and reduce output costs through new working methods (UNCTAD, 2024). However, despite the rapid pace of technological innovations and transformations, it appears that the expected increase in productivity has not kept pace with the speed of the digitalization process. Just as every change requires time within its own context for its economic or social impacts to become apparent, it is anticipated that the effects of digital transformation will also become more evident over time. To facilitate the pace of productivity in the digital transformation process, it is essential to first increase the market share of digitally capital-intensive firms equipped with advanced technology and to adapt business models to digital technologies.

2. An Overview of the South African Economy

In general terms, this section provides a foundation for understanding the economic implications of digitalization. The phenomenon of digitalization has long been the subject of extensive academic research (OECD, 2024). Evangelista et al. (2014), in their study on the EU-27 countries, stated that digitalization plays a stimulating role in terms of economic growth and employment (Kumar & Lee, 2024). Brynjolfsson and McAfee (2014) discuss the transformative potential of digital technologies in enhancing productivity and strengthening economic resilience. Schwab (2016) emphasizes the integration of artificial intelligence, big data, and automation as critical drivers of post-pandemic economic recovery. Hess et al. (2016) examine strategic approaches to digital transformation. Vial (2019) presents a conceptual framework for understanding the effects of digital transformation across sectors. Another study by Edquist et al. (2018) employs mobile broadband diffusion to assess the impact of digitalization on economic development.

2.1. Descriptive Statistics

Table 1. Descriptive Statistics

Variable	Patent Applications (Residents)	GDP Growth	Foreign Direct Investment	Inflation (Consumer Prices)	Trade of Goods	R&D Expenditures	Debt Service	Unemployment
Mean	8.62	2.20	1.70	5.24	50.20	0.71	3.95	22.56
Median	8.73	2.48	1.064	5.33	50.74	0.726	3.39	22.03
Maximum	9.12	5.60	9.66	10.07	67.88	0.80	8.36	28.83
Minimum	7.69	-6.16	0.20	-0.69	38.69	0.60	1.41	19.39
Standard Deviation	0.31	2.52	2.00	2.16	8.08	0.06	2.23	3.03
Skewness	-1.23	-1.36	2.84	-0.22	0.34	-0.18	0.60	0.71
Kurtosis	4.55	5.95	11.34	4.51	2.46	1.89	2.01	2.46
Jarque-Bera	8.83	16.85	106.21	2.62	0.80	1.40	2.52	2.43
Probability	0.01	0.00	0.00	0.26	0.66	0.49	0.28	0.29
Sum	215.69	55.11	42.56	131.06	1255.23	17.85	98.75	564.11
Sum of Squared Deviations	2.32	153.10	96.39	112.31	1566.99	0.09	119.80	220.78
Observations	25	25	25	25	25	25	25	25

While GDP growth has followed a fluctuating trend, unemployment has also exhibited notable changes. Foreign direct investment and inflation have experienced significant volatility across different periods, and the share of merchandise trade in GDP has shown variability. Research and development (R&D) expenditures, on the other hand, have followed a relatively more stable path. Overall, it is observed that economic indicators have displayed considerable fluctuations over time.

2.2. Correlation Analysis

Table 2. Correlation Matrix

Variable	Resident Patent Applications	GDP Growth	Foreign Direct Investment	Inflation (Consumer Prices)	Merchandise Trade	R&D Expenditures	Debt Service	Unemployment
Resident Patent Applications	**1**	-0.39	0.05	-0.10	0.72	-0.28	0.49	0.75
GDP Growth	-0.39	**1**	0.22	-0.06	-0.29	0.41	-0.54	-0.39
Foreign Direct Investment	0.05	0.22	**1**	0.15	0.11	-0.17	0.12	0.25
Inflation (Consumer Prices)	-0.10	-0.06	0.15	**1**	0.29	0.22	-0.02	-0.02
Merchandise Trade	0.72	-0.29	0.11	0.29	**1**	-0.10	0.55	0.73
R&D Expenditures	-0.28	0.41	-0.17	0.22	-0.10	**1**	-0.35	-0.42
Debt Service	0.49	-0.54	0.12	-0.02	0.55	-0.35	**1**	0.73
Unemployment	0.75	-0.39	0.25	-0.02	0.73	-0.42	0.73	**1**

Patent applications exhibit a strong positive relationship with merchandise trade and the unemployment rate, while showing a negative correlation with GDP growth. GDP growth is positively associated with foreign direct investment, but negatively correlated with total debt service and the unemployment rate. Inflation has a positive relationship with merchandise trade, while its associations with other variables are relatively weaker. Although R&D expenditures show a positive correlation with GDP growth, they are negatively associated with the unemployment rate and total debt service. Overall, there appear to be complex and interdependent dynamic relationships among the economic indicators.

2.3. Unit Root Test

Table 3. Unit Root Test

Augmented Dickey-Fuller				
Variable			ADF Statistic	p-Value
Resident Patent Applications	Level	Constant	-4.381532	0.0023
		Constant & Trend	-4.496807	0.0080
GDP Growth	Level	Constant	-3.783079	0.0090
		Constant & Trend	-4.977065	0.0028
Unemployment	Level	Constant	-1.025018	0.7273
		Constant & Trend	-3.100570	0.1286
	1st Difference	Constant	-5.288191	0.0003
		Constant & Trend	-5.102103	0.0023
Foreign Direct Investment	Level	Constant	-4.748845	0.0010
		Constant & Trend	-4.632793	0.0060
R&D Expenditures	Level	Constant	-3.145444	0.0365
		Constant & Trend	-5.093769	0.0031
Merchandise Trade	Level	Constant	-1.190153	0.6614
		Constant & Trend	-2.946891	0.1665
	1st Difference	Constant	-5.845384	0.0001
		Constant & Trend	-5.803606	0.0005
Inflation (Consumer Prices)	Level	Constant	-4.301168	0.0033
		Constant & Trend	-1.955107	0.0045
Debt Service	Level	Constant	-0.989289	0.7394
		Constant & Trend	-3.378910	0.0780
	1st Difference	Constant	-8.319401	0.0000
		Constant & Trend	-8.154455	0.0000

According to the results of the Augmented Dickey-Fuller (ADF) test, it was observed that the variables of resident patent applications, GDP growth rate, and foreign direct investment are stationary at level ($p < 0.05$). This suggests that these variables may require more in-depth analysis in terms of their long-term equilibrium relationships. On the other hand, it was found that the variables of unemployment rate, research and development expenditures, merchandise trade, and debt service are not stationary at level ($p > 0.05$), but become stationary after first differencing ($p < 0.05$). This indicates that these variables contain a unit root and must be differenced once to achieve stationarity.

2.4. Model Specification

In cases where variables are stationary at level and at first difference, and a cointegration relationship exists, the Error Correction Model (ECM) is employed. To determine the presence of cointegration, the F-bound test is applied.

- **F-Bounds Test**

Table 5.12. F-Bounds Test

F-BOUNDS TEST	Null Hypothesis: No Level Relationship Exists			
Test Statistic	Value	Significance Level	I(0)	I(1)
F-Statistic	11.76231	10%	1.92	2.89
K	7	5%	2.17	3.21
		2.5%	2.43	3.51
		1%	2.73	3.9

The F-statistic value has been calculated and found to lie outside the lower and upper bounds at conventional significance levels. Therefore, it is concluded that a cointegration relationship exists among the variables. Once this cointegration relationship is established, both long-run and short-run relationships between the variables can be analyzed within the ARDL model framework. In this study, the Hannan-Quinn criterion was used to determine the optimal lag length. The most appropriate model was identified as ARDL (1, 1, 1, 0, 0, 1, 1, 1).

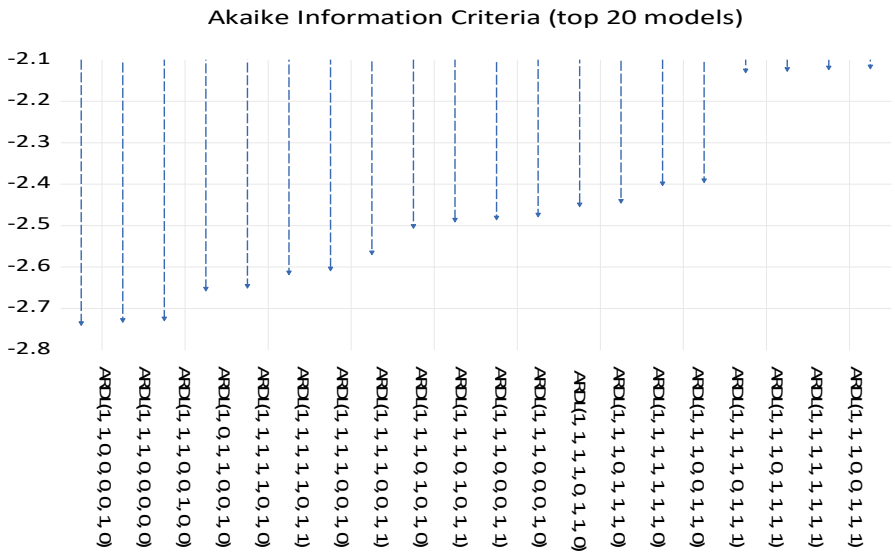

Figure 5.2. Hannan-Quinn Criteria

- **ARDL (1, 1, 1, 0, 0, 1, 1, 1) Model Estimation**

Table 4. ARDL (1, 1, 1, 0, 0, 1, 1, 1) Model Estimation

Dependent Variable: Resident Patent Applications				
Method: ARDL				
Sample (adjusted): 2000–2024				
Number of observations included after adjustments: 24				
Dynamic regressors (1 lag, automatic):				
Independent Variables: Inflation (Consumer Prices), GDP Growth, Foreign Direct Investment, Merchandise Trade Ratio, Research and Development Expenditures, Debt Service, Unemployment				
Constant term: C				
Number of models evaluated: 128				
Selected Model: ARDL (1, 1, 1, 0, 0, 1, 1, 1)				
Variables	Coefficient	Standard Error	t-Statistic	Probability
Resident Patent Applications	0.473756	0.093910	5.044798	0.0005
GDP Growth	-0.006671	0.007821	-0.852905	0.4137
GDP Growth (-1)	0.034878	0.009568	3.645231	0.0045
Foreign Direct Investment	-0.004318	0.008529	-0.506305	0.6236
Foreign Direct Investment (-1)	-0.032506	0.009196	-3.534776	0.0054
Inflation (Consumer Prices)	0.002468	0.009146	0.269890	0.7927
Merchandise Trade	-0.004896	0.004307	-1.136753	0.2821
Research and Development Expenditures	0.144521	0.276582	0.522527	0.6127
Research and Development Expenditures (-1)	-0.465360	0.233986	-1.988840	0.0748
Debt Service	-0.004880	0.008467	-0.576322	0.5771
Debt Service (-1)	-0.035452	0.010978	-3.229238	0.0090
Unemployment	0.106100	0.023144	4.584386	0.0010
Unemployment (-1)	-0.024123	0.017528	-1.376300	0.1988
C	3.338014	0.605258	5.515027	0.0003
R-squared	0.980127	Mean of the Dependent Variable		8.666631
Adjusted R-squared	0.954292	Standard Deviation of the Dependent Variable		0.249136
Standard Error of Regression	0.053264	Akaike Information Criterion (AIC)		-2.735924
Sum of Squared Residuals	0.028370	Schwarz Criterion (SC)		-2.048726
Log Likelihood	46.83108	Hannan-Quinn Criterion (HQC)		-2.553610
F-statistic	37.93819	Durbin-Watson Statistic		2.887382
F-statistic Probability	0.000001			

Statistically significant relationships have been identified between resident patent applications and several independent variables. In particular, foreign direct investment, research and development expenditures, unemployment, and total debt service exhibit notable effects.

While foreign direct investment does not have a significant effect on patent applications in the current period ($p = 0.6236$), it is found to have a statistically significant and negative impact in the previous period ($p = 0.0054$). Inflation and merchandise trade variables do not show a significant effect on patent applications in the current period. Although research and development expenditures do not have a significant effect in the current period ($p = 0.6127$), their lagged value shows a statistically significant negative impact ($p = 0.0748$). Similarly, total debt service is not statistically significant in the current period ($p = 0.5771$), but its value from the previous period has a significant and negative effect ($p = 0.0090$). The unemployment rate, on the other hand, has a strong and statistically significant positive effect on patent applications in the current period ($p = 0.0010$).

The overall fit of the model is quite high, with an R-squared value of 95%, indicating a strong explanatory power of the model in accounting for the variation in the dependent variable (patent applications).

2.5. Error Correction Model Results

- **Estimation Results of the Long-Run Relationship**

Table 5. Estimation Results of the Long-Run Relationship

Dependent Variable: Resident Patent Applications				
Variables	Coefficient	Standard Error	t-Statistic	Probability
GDP Growth	0.053601	0.022757	2.355322	0.0403
Foreign Direct Investment	-0.069976	0.023908	-2.926891	0.0151
Inflation (Consumer Prices)	0.004691	0.017693	0.265105	0.7963
Merchandise Trade	-0.009304	0.009228	-1.00822	0.3371
Research and Development Expenditures	-0.609677	0.639696	-0.953073	0.363
Debt Service	-0.07664	0.023163	-3.308721	0.0079
Unemployment	0.155776	0.032088	4.854663	0.0007
C	6.343087	0.625088	10.14752	0
EC = Resident Patent Applications – (0.0536*GDP Growth – 0.0700*Foreign Direct Investment + 0.0047*Inflation (Consumer Prices) – 0.0093*Merchandise Trade – 0.6097*Research and Development Expenditures – 0.0766*Debt Service + 0.155*Unemployment + 6.3431)				

When evaluating the long-run coefficients of the model, several statistical relationships were identified between the independent variables and patent applications. Although the effect of foreign direct investment is positive, it is not statistically significant ($p = 0.1825$). While the inflation variable shows a negative impact on patent applications, this effect is not statistically significant ($p = 0.6957$). The ratio of merchandise trade to GDP also has a negative effect, but its statistical significance is marginal ($p = 0.0863$). The effect of research and development expenditures is negative and statistically significant ($p = 0.0347$), indicating that R&D expenditures reduce patent applications. Although the unemployment variable has a positive effect, it is not statistically significant ($p = 0.2039$). The constant term (C) in the model is highly significant ($p = 0.0000$), generally reflecting the core dynamics of the model.

- **ARDL (1, 1, 1, 0, 0, 1, 1, 1) Error Correction Model Estimation Results**

In the next stage, an error correction model (ECM) was constructed to identify both the cointegration relationship and the adjustment of short-run disequilibria toward long-run equilibrium. The results of the estimated error correction model are presented in the table below.

Table 6. ARDL (1, 1, 1, 0, 0, 1, 1, 1) Error Correction Model Estimation Results

ARDL Error Correction Regression				
Dependent Variable: Resident Patent Applications				
Selected Model: ARDL (1, 1, 1, 0, 0, 1, 1, 1)				
Sample: 2000–2024				
Included Observations: 24				
ECM Regression				
Variables	Coefficient	Standard Error	t-Statistic	Probability
GDP Growth	-0.006671	0.003936	-1.694789	0.12100
Foreign Direct Investment	-0.004318	0.003476	-1.242466	0.24240
Research and Development Expenditures	0.144521	0.134053	1.078088	0.30630
Debt Service	-0.00488	0.004755	-1.026174	0.32900
Unemployment	0.1061	0.010037	10.57114	0
CointEq (-1)	-0.526244	0.038123	-13.80396	0
R-squared	0.913188	Mean of the Dependent Variable		0.047507
Adjusted R-squared	0.889074	Standard Deviation of the Dependent Variable		0.119200
Standard Error of Regression	0.0397	Akaike Information Criterion (AIC)		-3.402590
Sum of Squared Residuals	0.02837	Schwarz Criterion (SC)		-3.108077
Log Likelihood	46.83108	Hannan-Quinn Criterion (HQC)		-3.324456
Durbin-Watson Statistic	2.887382			

According to the results of the ARDL Error Correction Model (ECM), only the unemployment variable has a statistically significant short-run effect on the dependent variable, showing a strong positive relationship (coefficient = 0.1061, p = 0). Other variables—GDP growth, Foreign Direct Investment (FDI), Research and Development (R&D) expenditures, and debt service—were found to have no significant short-run effects (p-values > 0.05). The error correction term (CointEq (-1)) is statistically significant (p = 0), indicating that 52.62% of short-term deviations are corrected toward long-term equilibrium each period.

The model demonstrates a good fit, with an R^2 value of 91.32%, explaining over 91% of the variance in the dependent variable. The adjusted R^2 is 88.91%, confirming the model's explanatory power. The Durbin-Watson statistic is 2.89, suggesting the absence of autocorrelation. The values of the Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan-Quinn Criterion (HQC) further indicate that the model is well specified. Overall, the model provides a strong fit and offers valuable insights into the relationship between unemployment

and the dependent variable, while the error correction mechanism confirms the model's capacity to adjust toward long-term equilibrium.

2.6. Diagnostic Test Results

Table 7. Diagnostic Test Results

Diagnostic Test Statistics	Value	Probability
Normality (Jarque-Bera)	0.743701	0.689457
Serial Correlation (Breusch-Godfrey Serial Correlation LM Test)	4.953223	0.0631
Heteroskedasticity (Breusch-Pagan-Godfrey)	0.390262	0.9427

The Jarque-Bera test can be used to verify whether the model conforms to a normal distribution. The J-B statistic for the residuals was found to be 0.743701 and is not significant at the 5% confidence level ($p = 0.689457$). This indicates that the residuals of the model follow a normal distribution, allowing us to accept the null hypothesis. The Breusch-Godfrey Serial Correlation LM Test was used to check for autocorrelation. Since the LM statistic was 4.953223 and $p > 0.05$, it is concluded that there is no autocorrelation problem. Heteroskedasticity was tested using the Breusch-Pagan-Godfrey test, and the result was 0.390262 ($p = 0.9427$), indicating that there is no evidence of heteroskedasticity in the model.

Conclusion

The impact of digitalization on economies varies across regions. While the rapid adoption of digital technologies in developed economies has enhanced economic resilience, the lack of digital infrastructure in developing countries has slowed down economic recovery processes (Smith & Jones, 2024). This study aims to analyze the interaction between digitalization and the economy in the case of South Africa using econometric methods and data from the period 2000–2024.

The analyses reveal that, particularly in light of the literature review, digitalization—whose importance has increased in the aftermath of the pandemic—has notable effects on macroeconomic indicators (Li et al., 2025). These effects are evaluated through key variables such as economic growth, foreign direct investment, unemployment, inflation, merchandise trade, and research and development expenditures.

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