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Internet Penetration's Impact on Gross Domestic Product per Capita of African Countries

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Abstract
The internet has become an essential part of everyday life and is impacting various aspects of society. One field of interest is how internet usage affects economic growth, particularly in terms of GDP per person. This article aims at highlighting the effect of internet penetration on Africa countries gross domestic product per capita (GDP per capita). To achieve this, we used panel data for African countries over the period 1996 to 2019. The study conducted various statistical tests, such as causal effect, co-integration, and mediation tests, to identify which variables are useful in predicting GDP per capita. The findings show that the internet has a significant impact on the economy of African countries. Findings suggest that internet significantly impacts GDP per capita in African countries, whether evaluating within-effect (over time) or between-effect (across countries at a given time). In addition, the result reveals that Secure internet servers are fundamental if a country is to rely on the internet to boost its economy. The study highlights the need to invest in internet infrastructure and increase internet penetration to promote economic growth in Africa, due to the importance of the internet in today's world.
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1. Introduction

The internet connects devices and servers worldwide and enables the sharing of information and communication through digital media. Experts in economics, policy, and research are increasingly interested in the relationship between the internet and GDP per capita in African countries. The internet is crucial for economic growth and development in Africa, offering opportunities for businesses, access to education and healthcare, and fostering innovation and entrepreneurship. However, there is ongoing debate about whether the internet positively affects GDP per capita in African countries. Research has revealed that internet availability and usage have a positive impact on GDP per capita in African countries (Foster and Graham 2017). The internet has been instrumental in expanding access to international markets, enabling African companies to compete on a global level(Kristoffersen et al. 2020). The internet has improved access to education and healthcare, which has contributed to an increase in GDP per capita in Africa by providing access to information and resources (Dean et al. 2012). The internet plays a vital role in advancing social and political progress, creating opportunities for people and groups to connect, exchange information, and campaign for change, and promoting digital entrepreneurship, which has a positive effect on GDP per capita and employment. Additionally, businesses can expand to new markets through the internet, resulting in more economic opportunities and higher GDP per capita.

Despite this, assessing the real impact of internet penetration on GDP per capita in African countries requires further research, as there are still significant obstacles in terms of internet access and usage that need to be overcome. From the literature review, it can be seen that the internet has had a considerable positive impact on GDP per capita in African countries (Dewan and Kraemer 2000; Dimelis and Papaioannou 2010; Jalava and Pohjola 2002; Jorgenson and Vu 2005, 2010, 2011, 2016; Papaioannou and Dimelis 2007; Stiroh 2002a, 2002b)(Santiago da Costa, Pereira, and Akkari 2018).

This research aims to measure the impact of internet penetration on GDP per capita of African countries from 1996 to 2019. The goal is to assess the effect of the internet in Africa as a whole. The study will use within-effect and between-effect models and panel data analysis to evaluate the trend of GDP per capita regarding internet penetration over the years for each country. The statistical tests include co-integration and causal effect tests to examine the long-run relationship between GDP per capita and internet penetration, and to confirm if internet causes growth in GDP per capita. The main contribution of this study is to highlight how internet access impacts GDP per capita of African countries. The rest of this work is organized in five sections. Section 2 literature review, Data and hypotheses development in Section 3, Model construction Section 4, methodologies and results in Section 5, and Section 6 is the conclusion of the research.

2. Literature review

2.1. Overview of internet penetration in Africa

In 1994 only two countries have access to internet. This is south Africa and Egypt. In 2000 most countries had

internet access but the internet is limited only to the big cities (Wikipedia 2020). Today all Africa countries have access to internet with many rural area lacking access to internet (Hoffman and De Wet 2011). In Africa, the access to internet is only available in urban area. It's important to take into account this aspect when we want to set a model to evaluate the effect of internet on gross domestic product per capita (GDP per capita) of Africa countries. As mentioned above, in Africa, most of internet users live in urban area. we note a huge difference in internet access between urban and rural area. Those who use smart phone as devices are numerous in urban area compare to rural area. The urban area exceed rural by 200% (Magazine 2020).

Internet usage in Africa is lower compared to other parts of the globe. According to the International Telecommunication Union (Shahin 2010), the internet penetration rate in Africa was at 37.9% in 2020, while the global average was 59.5%. There are variations in internet usage within Africa, with some countries having high rates and others having low rates. Additionally, there are differences in internet usage between urban and rural areas in Africa, with urban areas generally having higher rates of internet usage.

There are several reasons for the low levels of internet penetration in Africa, including expensive internet access, limited infrastructure, and low levels of digital literacy. In recent years, efforts have been made to increase internet access in Africa, such as the African Union's "Vision 2063" (DeGhetto, Gray, and Kiggundu 2016) and the United Nations' "Connect Africa" program . These initiatives aim to improve infrastructure, make internet access more affordable, and promote digital literacy(African Development Bank 2013) to increase internet usage in the region.

2.2. Internet effect on economy

Several research works have been carried out over the past two decades in order to evaluate the relationship which exists between the penetration of the internet and the economy. (Stiroh 2005)conducted a study in 22 developed countries and 20 developing countries on the effect of ICTs on production between 1993 and 2001. He found that ICTs have a positive impact on the production. The same author (Stiroh 2002a) studied the effect of ICT on the American industry sector between 1984 and 1999. He finds that new technologies contribute negatively to the American economy. (Pohjola 2002)looked at the behavior of the economy between 1985 and 1999 in 42 countries. He finds that ICTs have no significant effect on the growth of the economy. (Dewan and Kraemer 2000) conducted a study to assess the effect of the Internet on the economy between 1985 and 1993. To arrive at their result, they considered 14 developing and 20 developed countries. His results show that ICTs have a positive effect on the economy of developed countries. However, the result is not significant for developing countries.

(Jorgenson, Ho, and Samuels 2011; Jorgenson and Vu 2005, 2010, 2016) studied the effect of internet on economy growth in Asian dragon and latin American countries. Their findings reported that internet has the same impact in developing and developed countries. (Papaioannou and Dimelis 2007) conducted a research in developing and developed countries in order to measure the impact of the internet on economy. They concluded that ICT influence more labor productivity in developed countries compared to developing one. A research is conducted in developing countries by (Yousefi 2011). He claims there is no significant influence of internet technology on the growth of economy. (Paunov and Rollo 2016) have studied the impact of the internet on the economy growth in 117 developing countries. they reported that the use of internet has positive and significant influence on economy. (Cirera 2016) has studied six African countries in order to get the effect of the internet on the productivity. He found there is no significant relationship between new technologies and productivity. However, he pointed out the effect of ICT on innovation. (Cardona, Kretschmer, and Strobel 2013; Indjikian and Siegel 2005; van Rijmenam 2014) have conducted a study related to the impact of the internet on economy in developed countries. The results indicate a significant effect of ICT on economy growth. (Dedrick, Kraemer, and Shih 2013) conducted research in 45 developing and developed countries in order to measure the influence of internet on economy growth between 1994 and 2007. He concluded there is significant influence of ICT on economy growth in both developed and developing countries. The same result was proved by (Maurseth 2018). Indeed, he studied the impact of the Internet on the development of the economy. His results show that there is a significant impact of ICT on the growth of economy.(Niebel 2018) studied the relationship between ICTs and the economy. To obtain his results, he considered the growth of the economy of 59 countries over the period 1995 to 2010. His results indicate that ICT has a significant influence on economy. (Salahuddin and Gow 2016) studied the effect of the internet on the South Africa economy. To achieve their results, they looked at the behavior of the economy over the period 1991 to 2013. Their results show a positive and long-run effect of internet use on economic growth. (Lapatinas 2019)examined the effect of the internet on the performance of the economy of 100 countries covering the period 2004 to 2015. His results indicate that there is a significant effect of the use of the internet on the economy.

(Watanabe et al. 2018)measured the digital economy share in GDP. They found that the change is significant with the advent of innovation in digital technology such as artificial intelligence, and mobile service. They underlined the paradox of productivity at the era of new technologies in industrialized countries.

One of the conclusions of the conference on the impact of the digital technologies on economies claims that internet of things is improving economy of countries all over the world. It enables to take advantage from e-commerce, big data, machine learning, and artificial intelligence (OECD 2018). This has the impact on economy and creates opportunity for business.

Talking about the correlation between GDP and internet penetration (Amiri and Reif 2013) has focused on developing countries that are leading in internet use to check whether the correlation exist or not. The results show an important correlation between the two variables. In addition, they proved that the direct driver of GDP growth is internet adoption.

(Hadavand 2011)studied the relationship between internet and economy growth in 244 countries between 1990 and 2011. His results claim the higher the number of internet users, the greater the effect on nominal GDP.

Internet users has a great effect on nominal GDP.

In view of this literary review, we realize that other researchers have focused more on the impact of the Internet on the economy in developed countries, in large firms. There is not a study that has been done to measure the effect of the Internet in African countries and especially in underdeveloped countries.

In summary, previous studies assert that the penetration of the internet has a positive impact on economic development., The penetration of the internet facilitates easy access to information. It also facilitates communication and collaboration, and promoting innovation and entrepreneurship. Overall, the articles provide valuable insights into the ways in which the internet has impacted economic development. The discussion leads to an important question about how the internet impacts the development of African countries, particularly in terms of GDP per capita. This question calls for a comprehensive analysis of the factors that influence the growth of the economy in Africa and its potential for future development.

3. Data and hypotheses development

3.1. Data

This research uses data collected from the World Bank site related to internet penetration, secure internet servers per 1 million people, GDP per capita, percentage of labor force, urban population, and population density in African countries. The data covers the period from 1996 to 2019 for Africa countries. Internet penetration is defined as the percentage of people with access to internet in the last three months, and secure internet servers as the number of secure servers per 1 million inhabitants. This research focuses on internet security as a key factor in assessing the impact of internet on GDP per capita, since security is necessary for using internet services. GDP per capita, urban population, population density, and labor force participation are also analyzed as variables. These variables were chosen to explain the impact of internet on GDP per capita, including the necessary variables of internet penetration and GDP per capita, as well as variables that take into account the country's geographical potential (Hausmann, Hwang, and Rodrik 2007). The study includes variables that may interact with the impact of internet on GDP per capita such as labor force, urban population, and population density. Labor force represents the human factor for production, urban population is necessary as internet access is generally available in urban areas, and population density may affect GDP per capita. The variables used in the research are summarized in Table 1, with a description of each variable provided in the table.

Table 1: Description of variable

Variable	Descriptions
Density population	People per kilometer square of land area
GDP per Capita	GDP divided by the population
Internet Penetration	Internet users divided by the population of the country
Labor force	percentage of total population aged 15 to 64 that is economically active
Internet Secure servers	Number of servers for 1000 inhabitant
Urban population	Number of the urban population divided by the population of the country

3.2. Hypotheses Development

To guide the research, certain hypotheses are proposed to be verified later, focusing on the effect of internet penetration on GDP per capita. The hypotheses are based on the findings of previous studies that have shown a positive effect of the internet on economic growth. The internet penetration has direct effect on GDP per capita. Indeed (Coase et al. 2016) claims that internet affects the development of economy. (Li 2019) also claims in his research that internet has great impact on economic. It promotes the development of economy. With the internet, the process of production is increased by the use of internet. Internet brings people together and the interaction between those people increase the value of the network and then impact the economy growth. (Manyika and Roxburgh 2011)for his part, says that the internet drives the economy growth. Internet constitutes a big part in GDP growth of Africa Countries.

*Hypothesis 1: "*Internet penetration has a great effect on Gross domestic product (GDP) per capita of Africa

countries".
Hypothesis 2: "The higher the GDP per capita, the easier Internet access would be for each inhabitant."
Hypothesis 3: Internet Secured Servers and Urban population are acting as mediator's variables on the effect of the Interne Penetration on GDP per capita.

4. Model construction

Empirical analysis of panel data is used in this research to explain the impact of the internet on GDP per capita. The panel model is suitable for this type of data, which includes several individuals, each with multiple observations over a given period. In this study, the data includes many countries, each with time series data from 1996 to 2019. The methodology includes checking for cross-sectional dependence, stationary of variables, and co-integration test to check for long-run relationships between variables in the panel data. The equation (1) is the panel model equation for this research.

$$Y_{it} = \beta_0 + \beta_1 X_{1,it} + \beta_2 X_{2,it} + \beta_3 X_{3,it} + \beta_4 X_{4,it} + \beta_5 X_{5,it} \quad (1)$$

Where,
Y_{it} is the "GDP per capita" for country i at time t;
$X_{1,it}$ is the "Internet penetration" for country i at time t;
$X_{2,it}$ is the "Labor Force" for country i at time t;
$X_{3,it}$ is the "Internet Secured servers" for country i at time t;
$X_{4,it}$ is the "Urban population" for country i at time t; $X_{5,it}$ is the "Density population" for country i at time t;
β_1 β_2, β_3, β_4, β_5 are the parameters of the model. Those parameters are respectively associated to "Internet Penetration", "Labor force", "Internet secure Servers", "Urban population", "Density population"

4.1. Cross-sectional dependence Test

The cross-sectional test proposed by (Baltagi, Feng, and Kao 2012; Breusch and Pagan 1980; Pesaran 2004, 2006)is the first statistical test to perform when dealing with panel data. A cross-sectional test in panel data is a statistical analysis that compares groups at a specific time to identify patterns, trends or differences. It allows for choosing between a null hypothesis of no relationship and an alternative hypothesis of dependence in this case, internet penetration in Africa countries. The test uses a statistic called the cross-sectional dependence statistic (CD) to check for dependence.

$$CD = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \left(\sum_{j=i+1}^{N+1} \sqrt{T_{ij}}\, \hat{\rho}_{ij} \right) \quad (2)$$

Where N refers to sample size, T refers to time, and $\hat{\rho}_{ij}$ refers to error term in cross-section correlation for country *i* and *j*.

4.2. Panel unit root test

A unit root test is a statistical test used to determine whether a time series is non-stationary or has a unit root. The most commonly used panel unit root test is the panel unit root test developed by (Pesaran 2014; Tugcu 2018). The test checks for cross-sectional dependence and allows for checking both individual-specific and time-specific effects. The null hypothesis claims a unit root (non-stationary) and the alternative hypothesis claims no unit root (stationary). The test is used to determine whether the panel data variables are stationary or not. Second generation unit root tests are more powerful than first-generation tests as they can detect unit roots even with cross-sectional dependence and individual-specific effects. The test is performed using an equation. (3).

$$\Delta X_{it} = \alpha_{it} + \beta_i X_{i,t-1} + \rho_i T + \sum_{j=1}^{n} \theta_{ij} \Delta X_{i,t-j} + \epsilon_{it} \quad (03)$$

Where Δ is the first difference operator X_{it} is variable, α_{it} is the intercept. *T* refers to time trend. The error term is ε_{it}.

4.3. Panel co-integration analysis

A co-integration test is a statistical test used to determine whether two or more-time series are co-integrated. Co-integration refers to a statistical relationship between two or more non-stationary time series such that a linear combination of them is stationary(Baltagi and Kao 2000; Tugcu 2018; White and Pettenuzzo 2014). Co-integration estimator in panel data is a method for analyzing the long-term relationship between multiple variables in a dataset that includes observations of several individuals over time. This estimator allows for investigating changes in the variables and connections between them, it is denoted by DF.

$$DF = \frac{t_\rho + \frac{\sqrt{2N}\,\sigma_v}{2\hat{\sigma}_{ov}^2}}{\sqrt{\frac{\hat{\sigma}_{ov}^2}{2\hat{\sigma}_\rho^2} + \frac{3\hat{\sigma}_{ov}^2}{10\hat{\sigma}_\rho^2}}}$$

Where $\hat{\sigma}_v^2$ and $\hat{\sigma}_{ov}^2$ are respectively the estimate of σ^2_v and σ^2_{Ov}. t_ρ is parametric t-statistic.

5. Results and discussion

Table 2 is the descriptive statistics table over the period 1980 a 2019. For representational reasons, we have` abbreviated some variables. For example, Denty.pop = Density of the population, GDP.capita= GDP per capita,

Table 2: Descriptive statistic

Variable	min	max	mean	median
Denty.pop	1.28	623.52	80.46	48.55
GDP.capita	102.60	1.62e4	1.60e3	741.7
Internet.Pen	0	75	10.66	3.28
Labor.Force	44.78	92.49	67.17	69.27
Net.Servers	0	2.64e5	1.68e3	4.93
Urban.pop	4.34	90.09	37.51	38.03

Internet.Pen = Internet penetration, Net.servers = Secure internet servers, and Urban.pop = Urban population.
In 1996, some countries lacked internet access, but now many have access. For example, 75% of Seychelles' population uses the internet at least every 3 months. The GDP per capita ranges from 102 to 1630 US dollars, with half of countries having a GDP per capita above 741.7

5.1. Trend of internet penetration

"Fig 1 shows the increasing trend of internet penetration in African countries. Most countries were at the beginning of internet penetration in 2000, but by 2019, many exceeded 20% penetration. The blue line represents the overall trend,

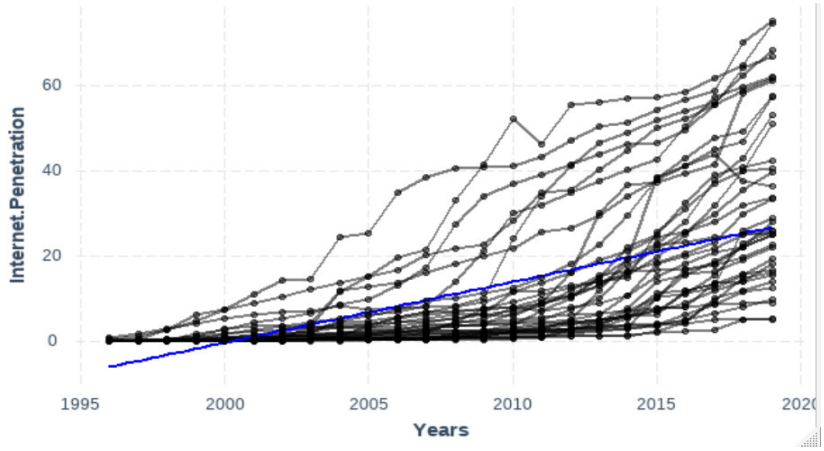


Fig. 1. Trend of internet penetration of Africa countries

Which has been steadily increasing. Data from the International Telecommunication Union (ITU) (Shahin 2010) shows that internet access in Africa has risen from 20% in 2005 to over 40% in 2020. Factors such as mobile internet services and affordable devices are driving this trend, as well as investments in infrastructure and programs to expand access in rural areas. However, internet penetration varies across regions and countries, with some countries having higher rates than others. On Fig 1, some countries have penetration beyond 60% since 2017.

5.2. Trend of GDP per capita

The Fig 2 shows the trend of GDP per capita growth in African countries from 1996 to 2019. In 1996, many countries had GDP per capita below 1500. From 2002, there was a change in the trend, with stronger growth. This coincides with the increasing importance of internet access in African countries. Overall, GDP per capita has generally been positive but with fluctuations. Data from the World Bank shows average GDP per capita increased from $1,200 in 2000 to $1,800 in 2019. However, growth varies among countries and regions, and is impacted by external factors such as commodity prices and political instability. Some countries, like Ghana, Ethiopia, and Rwanda, have been able to achieve high economic growth and improve GDP per capita. This

research will focus on factors related to internet access, labor force, and urban population.

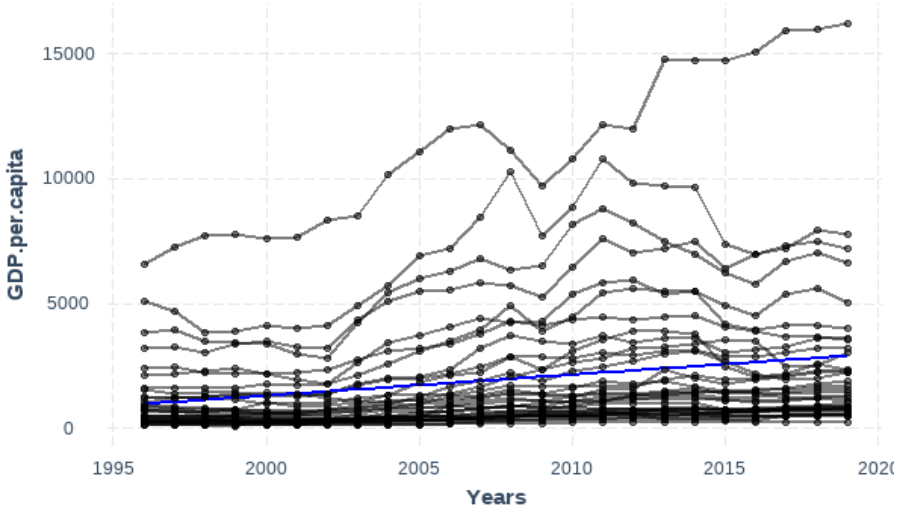
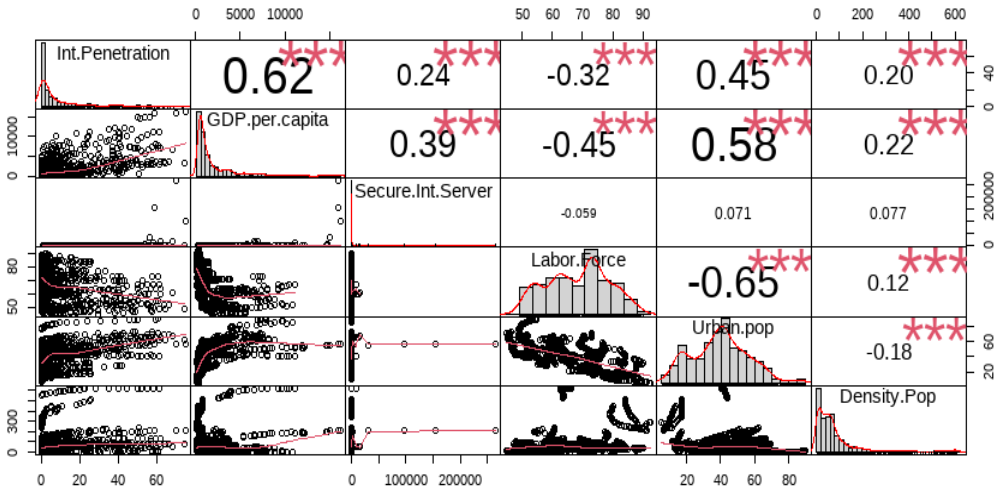


Fig. 2. Trend of GDP per capita of Africa countries

The Fig.3 shows a correlation between internet penetration, labor force, urban population, and density population with GDP per capita. The results indicate that GDP per capita is strongly associated with internet penetration, urban population, secure internet servers, and population density. However, it is negatively correlated with labor force. Next, we will conduct further statistical analysis to better understand the relationship between GDP per capita and internet penetration, including stationary and cross-section tests (Pesaran 2006).



*90% of significance; ** 95% significance; *** 99% of significance

Fig. 3. Correlation between variables

We will use the cross-dependence test (CD Test) to further analyze the relationship between GDP per capita and internet penetration. The results of the CD Test are presented in Table 3. The P-value from the test will indicate whether there is cross-section dependence for all variables except labor force. The P-value is less than 1%, indicating cross-section dependence at 99% confidence level.

Table 3: Cross sectional test

Variables	CD Test	P.value
GDP Per Capita	107.48	2.2e-16
Internet penetration	117.1	2.2e-16
Internet secured servers	68.425	2.2e-16
Urban Population	92.859	2.2e-16
Labor force	1.23	0.22
Density of population	123.21	2.2e-16

5.3. Unit root test

Table 4 and Table 5 are the results of the second-generation unit root test. This is to check whether there is stationary in our data. Unit root test through the ADF (Augmented Dickey-Fuller) approach indicates there is no unit root for all the variable. This means the variables are stationary. Likewise, Phillips-Perron unit root test (PP Test) approach also reveals no unit root for all the variable. This shows that variables are stationary.

Table 4: Phillips-Perron Unite root test

Variables	PP Test	P.value
GDP Per Capita	-61.065	0.01
Internet penetration	-162.21	0.01
Internet secured servers	-107.94	0.01
Urban Population	-49.921	0.01
Labor force	-45.469	0.01
Density of population	-46.126	0.01

Table 5: ADF Unite root test

Variables	ADF Test	P.value
GDP Per Capita	-5.72	0.01
Internet penetration	-8.10	0.01
Internet secured servers	-6.30	0.01
Urban Population	-5.30	0.01
Labor force	-4.66	0.01
Density of population	-5.07	0.01

5.4. Panel model estimation

In order to validate the model, it is necessary to identify appropriate independent variables for predicting the dependent variable of GDP per capita. To accomplish this, a causality test will be conducted to determine which independent variables have a significant impact on the prediction of GDP per capita. The objective is to identify the variables that have a causal effect on GDP per capita. TheTest of (Rosner and Kenneal 2018) is used to evaluate variables that affect GDP per capita. Table 6 presents the results of the causality test for predictor variables that influence the prediction of the dependent variable. The alternative hypothesis of the test posits that the predictor variable Granger-causes the dependent variable (GDP per capita). The tests were conducted at a 95% confidence level. The results suggest that Internet penetration, Secure internet servers, and Labor force are useful in forecasting GDP per capita in African countries. In other words, these variables have an impact on GDP per capita. The results also indicate that GDP per capita is a useful variable in predicting Internet penetration, meaning GDP per capita drives Internet penetration. However, the causal effect of Urban population and density population on GDP per capita is insignificant as the associated P-value is greater than 0.05. These variables remain as mediation variables as indicated in Table 7.

Table 6: Causality Test

Dependent variable	Predictor	Wald Statistic	p.value
GDP capita	Internet.pen	18.72	0.00
GDP capita	Net.Servers	15.18	0.00
GDP capita	Labor force	4.34	0.04
GDP capita	Urban.pop	0.20	0.66
GDP capita	Density.pop	0.20	0.66
Internet.Pen	GDP capita	0.20	0.00

In addition to the causality test, it is important to examine the mediation effects between variables. The test is conducted to identify the variables that act as intermediaries between internet penetration and GDP per capita)(Abu-Bader; and Jones 2021). Mediation variables are those that "stand in the middle" of the relationship between internet penetration and GDP per capita and help explain how and why independent variables affect GDP per capita. Table 7 presents the results of the mediation test between GDP per capita and internet penetration, using Sobel, Arion, and Goodman test methods. The values in brackets are the P-values of the estimated coefficients. The alternative hypothesis posits that the variables mediate between internet penetration and GDP per capita, and is accepted if the P-value is less than 0.05. The results indicate that Urban population, Secure internet servers, Labor force, and Density population are all mediation variables between internet penetration and GDP per capita. Whether using the Sobel, Arion or Goodman test, the results indicate that these

variables are intermediaries. Examining the long-run relationship between GDP per capita and other variables is necessary to better understand the relationship that exist.

Table 7: Mediation Test

Variable	Sobel	Aroian	Goodman
Urban.pop	10.18(0.00)	10.17(0.00)	10.19(0.00)
Net.Secure	3.78(0.00)	3.75(0.00)	3.81(0.00)
Labor.Force	7.23(0.00)	7.21(0.00)	7.25(0.00)
Density.pop	3.05(0.00)	3.02(0.00)	3.08(0.00)

The co-integration test of Engle-Granger (EG) was used to evaluate the long-term relationship between GDP per capita and other variables. The results, presented in Table 8, indicate that there is a long-term relationship between GDP per capita and Internet penetration, Internet secure servers, urban population, labor force, and density of population, as the P-value is less than 0.05. This suggests that there is a significant relationship between GDP per capita and these variables in the long-term.

Table 8: Co-Integration Test

Variables	EG Test	P.value
Internet penetration	-5.88	0.01
Internet secured servers	-6.31	0.01
Urban Population	-5.85	0.01
Labor force	-6.48	0.01
Density of population	-5.86	0.01

In summary, the panel model parameters in equation 1 were estimated and reported in Table 9 and Table 10. Table 9 shows the results of the within-effect model, which accounts for unobserved heterogeneity among individuals observed over time. The results indicate that internet penetration, labor force, and urban population have a significant positive effect on GDP per capita, as the associated p-values are less than 0.05. Specifically, an increase of 1 unit in internet penetration and labor force is associated with an increase of $29.78 and $60.81 in GDP per capita, respectively. An increase of 1 unit in urban population is associated with an increase of $69.62 in GDP per capita. Density population is not found to be significant as its p-value is greater than 5%.

Table 9: Within Effect Model

	Est.	S.E.	t val.	p.value
Internet.Pen	29.78	2.53	11.77	0.00
Labor.Force	60.81	10.78	5.62	0.00
Density.population	0.24	1.27	0.19	0.85
Urban Population	69.62	9.08	7.67	0.00

Table 10 Model shows internet penetration positively affects GDP per capita (108.12 coefficient, p<5%), urban population also positively affects GDP per capita (49.76 coefficient, p<5%), while labor force and density population do not significantly affect GDP per capita (p>5%).

Table 10: Between Effect model

	Est.	S.E.	t val.	p.value
Intercept	-1986.6	2081.47	0.95	0.35
Internet.Pen	108.12	39.26	2.75	0.01
Labor.Force	5.27	24.25	0.22	0.83
Density.population	2.90	1.97	1.47	0.15
Urban Population	49.76	18.36	2.71	0.01

6. Hypothesis verification

(Hypothesis 1): Our hypothesis that the internet has a positive impact on GDP per capita was verified. The panel model showed that internet penetration has a significant positive impact on GDP per capita, as proven by Table 9 and 10. The causality test (Table 7) also showed a causal effect. The co-integration test (Table 8) further showed a significant long-term relationship between internet penetration and GDP per capita.

(Hypothesis 2): The hypothesis wants to check whether the GDP per capita promotes access to the internet. In other words, the increase in GDP per capita over the years can lead to Internet access? Table 6 indicates through the causality test that GDP per capita has a causal effect on Internet penetration. The associated p-value is less than 5 %. This proves the significance of the results. In view of this, we claim that when the GDP per capita increases, internet access becomes easy. Because when GDP per capita increases, People are able to afford internet connection fees.

(Hypothesis 3): We used the Sobel, Arion, and Goodman mediation test (Table 7) to verify the variables that mediate the effect of internet penetration on GDP per capita. We tested urban population, internet secure servers, labor force, and population density. The test revealed that all these variables act as mediation variables, as the p-values were less than 5%. This means that internet penetration affects GDP per capita through these variables.

7. Conclusion

This research evaluates internet penetration impacts African countries gross domestic product per capita (GDP per capita). The main objective of this research is to study the impact of the internet on GDP per capita. To achieve this, we considered panel data of African countries regarding Internet penetration, Internet secure servers, GDP per capita, Urban population, Labor force, and Population Density, covering the period 1996 to 2019 to assess the effect of the Internet penetration on GDP per capita. The panel model that we implemented allowed us to get the results. The panel model sought to explain GDP per capita by internet penetration through control variables such as internet penetration, secure internet servers, labor force, and urban population. Internet penetration and Labor force are very decisive in the GDP per capita of African countries. The result indicates that internet penetration remains a fundamental lever for the economy growth. Whether in the within-effect model and the between-effect model, the internet penetration is significant to explain the growth of GDP per capita. Indeed, the within effect model seeks to explain the effect of internet penetration on GDP per capita in given country over the time. The result indicates that internet plays an important role in each country. The between effect which evaluate the effect of internet at a single time in different countries shows that the countries with a high penetration rate have a high GDP per capita. Secure internet servers remain important for any country that uses the internet as lever of economy growth. Internet security is important for all the countries that rely on internet to boost their economy growth. Through internet security, countries can take full advantage of the benefits of the internet. Our results indicate that Secure internet servers play a mediating role between penetration and GDP per capita. With regard to the Labor force, the finding indicate that it is a significant factor for each country. That is to say, the growth of Labor force leads to the growth of GDP per capita. The between-effect model tells us that the labor force is not significant when moving from one country to another. That is to say, if a country has a higher labor force rate, this does not necessarily mean the GDP per capita will be higher. In view of these results, we recommend African countries to bet heavily on internet penetration if they want to see their country progress in terms of GDP per capita. It will be also necessary to set up Secure Internet servers, because the two infrastructures work together. The labor force is also an important lever for African countries. We strongly advise decision-makers in African countries to ensure that internet penetration is effective by installing all necessary infrastructures that enable the good internet access. Because access to the internet by the inhabitants of the countries makes it possible to push the growth of their economy effectively by increasing GDP per capita. The authorities must ensure that the infrastructure is in place to allow good access to the Internet for all citizen of their countries.

In this work, we fail to take into account all the factors that contribute to the growth of economy such as world share index, enterprise effect on GDP. Therefore, we invite scholars to consider those aspects while dealing with such topic regarding the impact of internet penetration on nominal GDP of Africa countries.

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