A sustainable economy for Senegal: A transition to a digital-based economy

Mr. Souleymane NDIAYE

Doctoral School of Sustainable Development and Society (ED2DS)

Research Center in Applied Economics and Finance of Thiès (CREFAT)

University of Thiès – Senegal

Email : souley.ndiay@gmail.com

Abstract

The purpose of this article is to analyze the sustainability of the Senegalese economy towards a digital transition. To do this, this work focused on modeling the relationship between digital technologies and economic growth. We applied the ARDL (Auto-Regressive Distributed Lag) estimation method to model the long-term and short-term dynamics of the impact of the digital economy on economic growth in Senegal. The results of the estimates, as part of the specification used, lead to the conclusion that there is a positive impact of information and communication technologies (ICT) on economic growth. These results are mainly due to the productive nature of investment and factor productivity.

Keywords: *sustainability, digital economy, growth, ARDL estimate, Senegal*

JEL Classification : C52, D24, O47

1. Introduction

In the middle of the years 1990s, Senegal opened up to expansive outward growth, coinciding with the wave of liberalization and the international financing program, which aimed to lift the Senegalese economy, such as most African countries, fails to achieve sustained, sustainable and inclusive economic growth. Today, faced with such an economic policy adopted in Senegal, the growth rate of its Gross Domestic Product (GDP) has reached 7.1% and the digital economy, like telecommunications, represents 5.1%. % in economic growth *(DPEE, 2017)*.

This digital technology sector is one of the most important pillars of its socio-economic development policy. Thus, in its ramps towards emergence, Senegal has decided to adopt a new development model called SPE[1] , which is the benchmark of its economic and social policy in the medium and long term. So

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[1] Emerging Senegal Plan (SPE), a new develop>ment programme aimed at achieving the country's economic emergence by 2035. It is built on three pillars: the structural transformation of the economy and growth; the human capital, social protection and sustainable development; governance, institution, peace and security.

the impulse is to facilitate and accelerate the transition of many sectors whose development is essential to the realization of this ambition, including that of the digital economy. To this end, the telecommunications industry is the foundation on which the digital transition of all sectors of its economy is based, through a Digital Strategy (*SN2016-2025*).

With the effects of globalization, the world is changing at an unprecedented rate, driven by digital technologies, namely: The Internet, computing, the Internet of Things, big data, open data and startups ... As a result, the activity of this sector in Senegal was supported by the good performance of commercial activities and telecommunications. For the latter, mobile telephony and the internet continue to grow thanks to competition between these operators (Orange, Tigo and Expresso). The activity is up 5% in 2016 against + 3.3% in 2015, this situation is marked by the level of the penetration rate exceeding the 100% mark in mobile telephony with the advent of 4G[2]   (DPEE, 2017; ARTP, 2017).

At the continental level, the report by Legatum Institute[3], face Senegal in the place. This progression is due to the improvement in the areas of personal freedom and governance. But also 1st African country, in terms of I-GDP[4] estimated at 3.3%, because of a very good international connectivity and a good national transmission network. It remains that in Senegal, the decomposition of I-GDP, shows that 91% of its value is due to private consumption while the other dimensions such as the contribution of public investment and the export of technologies are almost low, or 7% of imports against 2% of exports, according to (*WTO, 2017*).

This context places this country in an international market environment, characterized by the results of technical progress, which now shifts the evolution of our societies through the use of digital technologies. The latter constitute the emblem of a decisive sector for the economic and social development of all the developed countries, as well as the countries in the process of development and so-called emerging ones. Digital technology is also, in Gille view, (2009) an essential factor in multiplying the productivity gains and increasing the competitiveness of all sectors of the classical economy, through the supply of goods and services that have undergone important transformations.

Indeed, our study intends to explore these upheavals and demonstrate the interest of considering a transition that is compatible with the socio- economic needs of the country. By suggesting policies aimed at to promote and boost investment, in terms of infrastructures in the Information and Communication Technologies (ICT) sector, both in the formation of human capital and major innovation in Small and Medium Enterprises (SME) and Startups. What are they key factor for the country to catch up other developed countries and so-called emerging countries. In addition, the effort to develop SMEs and startups

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[2] Fourth generation communication standard for mobile telephony corresponding to LTE-Advanced (IMT-Advanced). Succeeding 2G, 3G and 3.5G (HSPA)

[3] This ranking "AfricaProsperity 2016", is based on (38 African countries according to their prosperity) the levels of GDP per capita as well as on the 89 factors that it groups in eight broad categories: the economy, the presence of opportunities entrepreneurship, governance, education, health, safety, personal freedom and social capital.

[4] Weight of the Internet in the economy (I-GDP) in 2017

are in this sector should be intensified to effectively against competitors, whether they are producers of digital technology Asiatic equipment or intermediate of Internet Americans.

However, will promote to further support the local economy in the opportunity to follow the shift to the digital-based economy, through the channel of ICT investment and production factors. Therefore, the use of digital technology consists levers allowing to ass conditions for competitiveness and sustainable growth. The concept of the digital economy arises from the impact and influence of ICTs on other economic sectors, fostering the integration of other technologies such as mobile and the Internet at different levels of the value chain.

Beyond, their direct or indirect contributions in the economic system, in addition so that we can see where to observe this transition of the digital economy on economic growth in Senegal. It is imperative that services derived from these digital technologies represent a significant part of economic growth. Especially thanks to positive externalities, telecommunication networks are an ideal platform for innovative services, the creation of new markets and services. This has important effects in terms of economic openness and the creation of many jobs. These technologies have the most impact especially in: access to information, financial transactions, traceability, capacity building and management of financial products.

The search for answers to these vital concern leads to direct our paper in the study of sustainability by the transition of digital technologies in the Senegalese economy.

The purpose of this article is to analyze the sustainability of the Senegalese economy towards a digital transition. The main hypothesis states that there is a positive and significant effect on economic growth through, the determinants of investment and productivity. This assumption is acceptable to the extent that most of the empirical works that we will observe, attests the positive contribution of the sustainability of the Senegalese economy through a transition through ICT. To reach c and objective, we use an ARDL (AutoRegressive Distributed Lag) model to model the dynamics of long and short term.

This article is all the more interesting because it seems to be the first empirical research work devoted to analyzing the impact of transition-based digital technologies on economic growth in Senegal. The rest of this article, which is based on data from WDI (World Development Indicators and "*conference total economy board database, 2017*", is structured around four sections. The first section presents the approach of the theoretical and empirical review. The second section proposes a methodological analysis. The third section presents the results and the interpretation of the econometric estimates. The fourth and last section of this article is devoted to the conclusion and recommendation.

2. Literature review

Based on neoclassical models, much theoretical and empirical literature is devoted to analyzing the impact of digital technologies on economic growth. In recent decades, the evolution in terms of massive investments in digital technologies, tangible or intangible, has accompanied significant improvements in living standards, making the capital and work more flexible and less dangerous.

To this end, according to D' souza and Williams (2017), digital technologies are transforming the way economic activities function, by facilitating tasks that are highly dependent on connectivity, use of information, forecasts and collaboration. For these authors, the economic activity of today's companies has

an organizational capital, a high-quality personnel management and decision- making process, and then capital human, whose workforce is highly qualified. To achieve this, we must invest a plausible art of digital technologies, able to influence productivity gains.

Next to this transition in the economic fabric, digital technology for Varian (2016) outlines five major ways in which they transform activities in all sectors. On the outskirts, in the sectoral level, digital technologies are likely to generate efficiency gains, then to offer companies opportunities to increase their profits and shares market and foster innovation continue, say these authors (Davis, Haltiwanger and Cao, 2014). In addition, the ICT revolution in growth and productivity has been closely tied to human activity, namely the entertainment, communications, and computing collection and processing sectors (Gordon, 2016). It also stresses that the employment share of new business represents "*an important source of new technologies and creative destruction*". For the author, since 2000, these technologies are used in various spheres and s have evaluated   the following way: Ubiquity[5] Affordability[6] , Reliability[7], Speed[8], Conviviality[9] and know-how[10].

However, evolution activities, through digital technologies s encounters limits in terms of transition. According to Van Ark (2016), only a small number of companies in the United States, the United Kingdom and Germany are making a complete transition to the digital economy. As a result, few sectors and industries have recorded high productivity gains to date. In his opinion, the advanced economies are still at the installation stage, a long period in which the technologies are developed and grew under the leadership of how new techniques and methods of production, which nevertheless disrupt practices and established organizations.

For the author, efficiencies may only be realized at the deployment stage, a stage where technologies are widely used and fully integrated into both the business and their relationships with customers and suppliers. Therefore, during the installation phase, innovations do not spread quickly in all companies in the same sector, because the first to successfully adopt brakes old technologies and their applications according to "*creative destruction*" (Schumpeter, 1939 and 1947). He also argues that this process may initially slow down the potential growth of the economy due in part to a structural shift in the labor force (Keynes, 1931).

The impact of the transition of digital technologies through the revolution brought by these technologies allows us to shed light on how this diffusion process unfolds. Empirical studies of Gordon, and Kretschmer Strobel (2013), consider that the impact of productivity in business investment in ICT, highlight a 10% increase in such investment leads an increase 0, 5 to 0.6% of production.

Nevertheless, for some authors from Baldwin and Gu (2013 and 2014), the diffusion of digital technologies results in significant gains in terms of economic growth. Today other sectors intervene in this dynamic,

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[5] Extent to which consumers and businesses have universal access to digital services and applications;

[6] Extent to which the price range of digital services makes available to as many people as possible;

[7] Quality of digital services available;

[8] Extent to which digital services can be accessed in real time;

[9] Ease of use of digital services and the ability of local ecosystems to implement these services;

[10] Ability of users to integrate digital services into their lives and their businesses.

especially in the (utilities, information and culture, arts and entertainment), and in areas heavily knowledge-intensive and optics (professional, scientific and technical services, advanced manufacturing).

Several recent studies show that the positive and significant effects of digital technologies on productivity. The use of digital goods and services as the computer, information technologies and the Internet have effects that go well beyond productivity. In the same way as e-commerce, it reduces transaction costs and increases market transparency, according to (Leypoldt and House, 2017). They shall also allow consumers to make purchases conveniently and efficiently, while improving levels and living conditions beyond the real GDP growth (Hulten and Nakamura, 2017).

The main mechanism by which ICTs can influence short-term economic growth has been mainly explained by Cette and Kocoglu (2000 and 2005), then by Blanchet et al. (2005). For these authors, the diffusion of Information and Communication Technologies (ICT) favors a progressive process. In addition, the rise in potential output growth and labor productivity induced by this diffusion is therefore regular. On the other hand, with regard to the studies by Cette and Sylvain, (2003), they show that the fall in unemployment over the period of the study was accompanied by a decrease in the corporate margin rate and a subsequent depreciation. the increase in the wage bill. This explains why, the basis of inflation by the compression of the margin of the companies of this sector.

Better, according to Cette, Kocoglu and Mairesse, (2005), the influence of digital technologies is likely to affect economic growth in the medium and long term by two types of effects:

First, the Global Productivity Productivity (FGP) gains from progress in the ICT-producing and ICT-using sectors. Therefore, at constant amounts of capital and labor, these gains increase production (FGP). This effect can be explained for them, in the following way: ICTs generate particularly positive externalities such as network effects, in terms of gains allowing information exchanges. In the context of growth accounting, the gap between actual return and the estimated return on the compensation component is then mechanically affected by overall factor productivity. In addition, technical progress makes it possible to produce a larger volume of production from the same factors. So, part of the benefits of the production process goes to third parties, in other words generating external effects.

Secondly, for these authors, the substitution effects between the factors of production, notably what is manifested by an increase in the capital-to-capital ratio, by a capital substitution at work, associated with the accumulation of ICT capital in the sectors. ICT users.

Always according this, Kocoglu and Mayor, the confirm study that productivity global factors and the amount of travail constant, this increase in capital will increase production. This accumulation is stimulated by lower ICT prices. The substitution of intensive factors for ICT capital, produces less intensive factors resulting in the evolution of the relative prices of these types of factors. Thus, with the fall in prices of computer equipment, the constant quality in relation to wages or the price of use of other capital goods, can be observed as one of the engines of the increasing computerization of production processes.

However, in Senegal, like most countries, South Korea, after several reforms in its economic fabric since the 1970s, has achieved almost 15 times more real GDP than Senegal in 2017. If in Asia and some African countries where Botswana or Tunisia have made enormous progress in the field of ICT since the end of the

1990s. This is mainly due to the high rates of economic growth technology capitals, thereby significantly improving the living conditions of their populations. In fact, they are among the 13 economies identified by the UN Commission on Growth and Development that have achieved an average economic growth of 7% for a quarter of a century.

Contrary to the Senegalese economy, according to Diop (2017), to understand why this economy has not achieved such a feat, it is necessary to identify the explanatory factors of the growth of the Senegalese economy. Thus, the analysis is based on the growth accounting method, which also allows the use of the long-term production function. It represents a technique that decomposes the growth of output over a period of time by the contribution of capital, labor, and total factor productivity (TFP). In this term, the decomposition of growth between 1980 and 2010 shows a shocked evolution of TFP with a slight improvement in the period.

Since then, the proliferation of automation by artificial intelligence and the progressive use of technology in industrial and non-industrial sectors, sparked debate in the future regarding the use of the amount of labor demand. While, digitization could lead to an increase in productivity and growth in potential output. All things being equal.

In accordance with, Brynjolfsson and McAfee (2015), transition to a digital economy, are likely to see an increase in skills asymmetry and long-term unemployment, as well as a slowdown in the growth of potential output. Considering, significant changes brought digital, there is always risk that turnabout s impact on the trend that affects socio-professional category (Meyer, 2011). The author shows that young people are more productive than older people, because they can master new technologies and keep abreast of technological changes.

This brief theoretical and empirical review shows the predominant role of digital technologies, whatever their form, in the results by country. It thus remains normal to question the methodology and after thinking about the estimate, in order to confirm or refute the main hypothesis of this paper.

3. Methodology and data

To analyze the effect of the sustainability of the Senegalese economy through a transition to digital basis, we use modeling Auto-Regressive Distributed Lag (ARDL), the cointegration test across Pesaran et al (2001), which is a dynamic model. The latter takes into account the temporal dynamics (adjustment period, anticipation etc.) In doing so, it allows to estimate the short-term dynamics and the long-term effects for cointegrated series or even integrated at different orders, adopted in the test approach at the terminals of Pesaran and Shin (1995), Pesaran and al (1996) and Pesaran et al (2001).

3.1. The model

In the family of dynamic models, we divide three types of models, insofar as we consider the dependent variable « Y_t» And the independent variable « X_t », we accept than :

✓ With the autoregressive models (AR), they represent dynamic models in which we find among the explanatory variables « Y_t» the dependent variable, which is in implicit form:

$Y_t = f(Y_t, Y_{t-p})$ the autoregressive term translates, the regression of a variable on itself, or on its own lagged values.

✓ Delayed models or distributed lag (DL) are dynamic models that have explanatory variables « X_t », and its past or off-set values; takes a form that follows : $Y_t = f(Y_t, Y_{t-q})$, The term lag, showed that short-term effects « X_t » on « Y_t » Are different from those in the long run. In terms of time, the response scales of Y_t to the change of X_t different.

✓ Autoregressive Time Delayed Models (ARDL) represent models that combine features from two of the above; the explanatory variables (X_t), the dependent variable shifted (X_{t-p}), and the past variables of the independent variable (X_{t-q}). They have this following general form:

$$Y_t = f(Y_t, Y_{t-p}, Y_{t-q})$$

However, dynamic models have problems of autocorrelation of errors, with the presence of the endogenous variable shifted as explanatory (model AR and ARDL), and multi-collinearity (like DL and ARDL). This complicates that, in fact, the estimate of least ordinary squares (OLS). Thus, to overcome these problems, it is important to use robust estimation techniques (SUR method, etc.). This constitutes a possibility that the variables considered in these models should be stationary, in order to avoid fallacious regressions. So explicitly, the ARDL model is written as follows:

$$Y_t = \varphi + \alpha_1 Y_{t-1} + \ldots + \alpha_p Y_{t-p} + \beta_0 X_t + \ldots + \beta_q X_{t-q} + \varepsilon_t$$

Or

$$Y_t = \varphi + \sum_{i=1}^{p} \alpha_i \, Y_{t-i} + \sum_{j=1}^{q} \alpha_i \, X_{t-J} + \varepsilon_t$$

With $\varepsilon_t \sim (0,\sigma)$, which constitutes the error term; « β_0 » Translates the short-term effect of X_t on Y_t. If we consider the following long-term or equilibrium relationship « $Y_t = k + \phi X_t + u$»; otherwise we can calculate the long-term effect of X_t on Y_t (is « ϕ ») as following :

$$\Phi = \sum b_j \, / \, (1 - \sum \alpha_i)$$

As with any dynamic model, the information criteria (AIC, SIC and HQ) will be used to determine the optimal offset (p * or q *); an optimal offset is one whose estimated model offers the minimum value of one of the stated criteria. These criteria are: Akaike (AIC), Schwarz (SIC) and Hannan and Quinn (HQ); their values are calculated as follows:

$$\text{AIC (p)} = \log \left| \widehat{\Sigma} \right| + \frac{2}{T} n^2 P$$

$$\text{SIC (p)} = \log \left| \widehat{\Sigma} \right| + \frac{logT}{T} n^2 P$$

$$HQ\ (p) = \log\ \left|\hat{\Sigma}\right| + \frac{2logT}{T} n^2 P$$

With $\hat{\Sigma}$ representing the matrix of variances and covariance of estimated residues; T = observation number; p = lag or lag of the estimated model; and n = regression number. All of these dynamic models can help capture the short-run dynamics and long-run effects of one or more explanatory variables on a variable to explain. This will be possible only if the time series of the study are cointegrated, allowing the estimation of a Model Correction of Error (ERM).

3.2. The data

As for the source of the data used, they come from the reconciliation of two WDI database files (World Development Indicators and " *conference total economy board database, 2017* ".

Thus, the variables used take into account the time dimension from 1987 to 2017. The basic sample is Senegal, this chronological choice was made in relation to the availability of the data, according to the variables of the study and the chosen period.

Variables	descriptions	Expected effects
GDP	Product GDP per capita, expressed in USD	
KTIC	Technological capital	+
KHTIC	Non-ICT Technology Capital	+
KHUM	Human capital	+
TRAV	Labor employed (labor force)	+
GPF	Global Productivity of Factors	+
$\varepsilon_t \sim (0,\sigma)$	Constitutes the term error	
β_0	Translates the short-term effect of X_t on Y_t	

Figure 1 : Variables used

Source: estimate statistician CREFAT

4. Analysis of the results of the econometric estimations

4 .1. Results of unit root tests

The study of stationarity is essential before the processing of a chronological series, in order to know the stochastic characteristics (its hope and its variance). If the last two, are modified over time, then the series is not stationary. In the opposite case, when they are invariant, the series is stationary. Generally used Augmented Dickey-Fuller test for all variables in the model to check stationary or not Stationarity of the series. If it is stationary, the process stops. Otherwise we proceed to the process DS (differency Stationary) to make it stationary.

variables	Level	First difference	Order of integration
LGDP	-2.514669	-4.241258**	I(1)
LKTIC	-2.540868	-2.686313*	I(1)
LKHTIC	-2.161492	-5.738538	I(1)
LKHUM	-2.446606	-5.830081***	I (1)
LTRAV	-2.150853	-6.511963***	I(1)
LGPF	-0.294932	-1.761087*	I(1)

Figure 2: Results of unit root tests

Source: estimate statistician CREFAT

***, **, *, are the significance thresholds respectively at 1%, 5%, 10%

The results of the table (2) show that the series tested meet the different thresholds of probability s fixed, so it is not possible to reject the hypothesis of non-stationarity of the time series studied. In other words, this means that all variables represent a unit root tested series are cointegrated to order s different according to the degree of differentiation (constant consistency and trend and no trend or consistency). From these tests, we can say that the model is integrated of order 1. In this case, we plan to use the test approach at the terminals of Pesaran and Shin (1995), Pesaran et al (1996), Pesaran et al (2001).

4.2. Cointegration test

The cointegration test adopted here responds to that improved by Pesaran et al (2001). So, in its application there are two steps to follow: In the first place, it is important to determine the optimal offset (AIC, SIC); then use the Fisher test to test cointegration between the series.

4.2.a. Optimal offset of the ARDL model

To do this, we use the Schwarz Information Criterion (SIC) to select the optimal ARDL model, through meaningful statistical tests.

Table1 : Model ARDL (1, 3, 2, 3, 3, 0)

Dependent variable: LGDP				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LGDP(-1)	0.334171	0.126544	2.640738	0.0247
LKTIC	0.011464	0.069103	0.165893	0.8715
LKTIC(-1)	0.210418	0.101445	2.074208	0.0648
LKTIC(-2)	-0.282296	0.093955	-3.004573	0.0132
LKTIC(-3)	0.340492	0.060297	5.646955	0.0002
LKHTIC)	0.044819	0.017955	2.496262	0.0316
LKHTIC(-1)	-0.021624	0.018510	-1.168200	0.2698
LKHTIC(-2)	0.070678	0.019112	3.698034	0.0041

LKHUM)	-0.015260	0.054384	-0.280597	0.7847
LKHUM(-1)	-0.034652	0.053961	-0.642162	0.5352
LKHUM(-2)	-0.078890	0.064605	-1.221101	0.2501
LKHUM(-3)	-0.183951	0.052602	-3.497007	0.0058
LTRAV)	0.530565	0.318104	1.667899	0.1263
LTRAV(-1)	-1.111446	0.441178	-2.519270	0.0304
LTRAV(-2)	0.570255	0.359123	1.587909	0.1434
LTRAV(-3)	0.435853	0.299563	1.454963	0.1763
GPF	2.23E-05	2.05E-05	1.090433	0.3011
C	-1.475032	1.236144	-1.193252	0.2603

R-squared	0.996740	**F-statistic**	
179.8369			
Adjusted R-squared	0.991197	**Prob(F-statistic)**	
0.000000			
		Durbin-Watson	
1.954881			

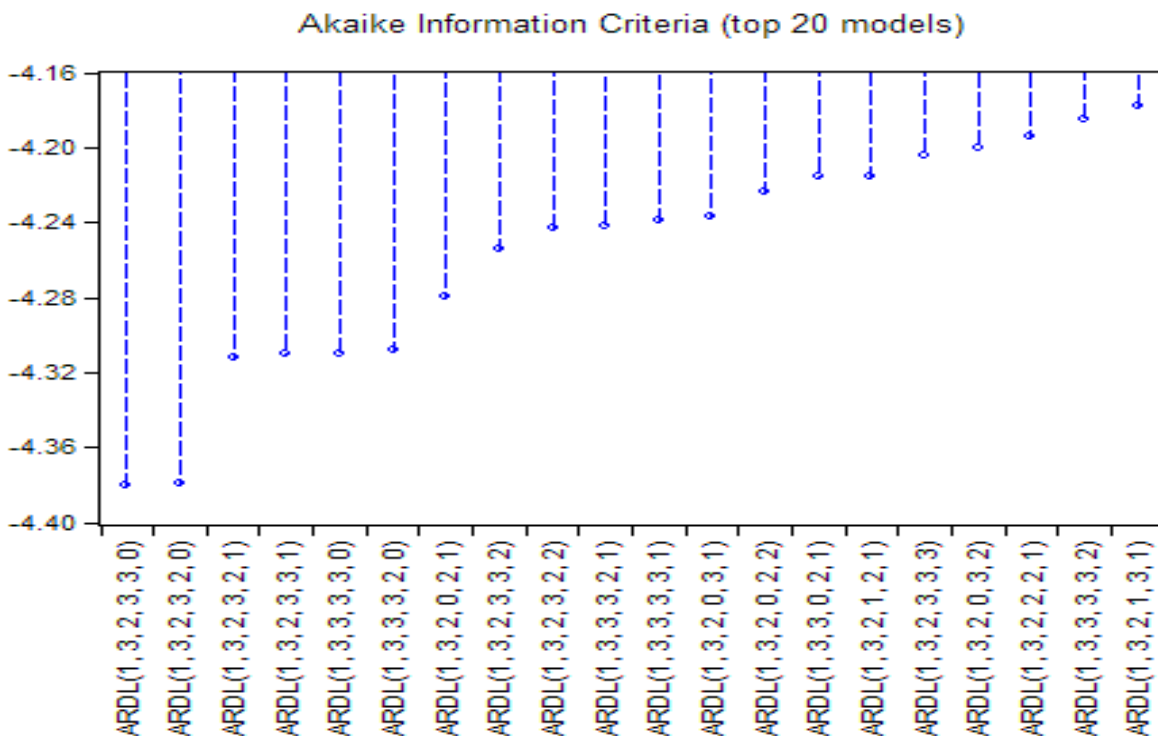Source: estimate statistician CREFAT

Chart 1: Representation of Values (AIC)

Source: estimate statistician CREFAT

We note that with this model ARDL (1, 3, 2, 3, 3, 0), represents a much more optimal character among the 16 tested, because it offers the smallest value of the AIC.

However, these tests allowed us to diagnose the estimated model, and to see if there is autocorrelation of errors. This situation shows that there is no heteroscedasticity, so their normality errors and the ARDL model is well specified.

Table 2: Diagnostic test results of the estimated ARDL model

Test hypothesis	tests	Values (probability)
autocorrelation	Breusch- Godfrey	0.11 (Prob.0.89)
heteroscedasticity	Breusch- Pagan-Godfrey Arch-test	1.72 (Prob.0.19) 5.39 (Prob.0.02)
Normality	Jarque-Bera	4.71 (Prob.0.03)
Specification	Ramsey (Fisher)	0.60 (Prob.0.45)

Source: estimate statistician CREFAT

In this case, the null hypothesis is accepted in all series. So, the model is thus validated statistically. Therefore, the ARDL model (1, 3, 2, 3, 3, 0) view, is generally significant and express the order of 99%, in terms of a dynamic of the presence of digital technologies in the Product Real Gross Domestic Product (GDP) per capita in Senegal, 1987 to 2017.

4.2.b. Cointegration test at the terminals

This cointegration test of Pesaran et al (2001) allows to calculate the statistical value of Fisher which will be compared to the critical values that form bounds as follows:

If Fisher> upper bound: cointegration exists

If Fisher <lower bound: Cointegration does not exist

If lower bound <Fisher <upper bound: No conclusion

variables	*LGDP, LKTIC, LKHTIC, LKHUM, LTRAV, LGPF*	
F-stat , calculated	4.43	
Critical threshold	Landmark <	Landmark >
1%	3.41	4.68
5%	2.62	3.79
10%	2.26	3.35

Figure 3 : *results of the cointegration test of Pesaran et al (2001)*

Source: estimate statistician CREFAT

The results of the test at the Pesaran terminals confirm the existence of a cointegration relation between the series in the upper bound Fisher test. This situation first makes it possible to test the correlation between the variables retained; and finally, to estimate the long-term effects.

4.3. Model Correlation and causation between variables
4.3.a. Correlation test between variables

The model, in other words the simple correlation matrix between the variables in the table below, gives the degree of association between the variables.

Table 3: Matrix of simple correlation between variables

	LGDP	LKTIC	LKHTIC	LKHUM	LTRAV	L GPF
LGDP	1 .000000 0	0.974845	0.456972	0.973914	0.982590	-0.328267
LKTIC	0.9748451	1.000000	0.447745	0.962485	0.961340	-0.293763
LKHTIC	0.456972	0.447745	1.000000	0.377979	0.343696	-0.199158
LKHUM	0.9739143	0.962485	0.377979	1.000000	0.977188	-0.403204
LTRAV	0.982590	0.961340	0.343696	0.977188	1.000000	-0.321675
L GPF	-0.3282674	-0.293763	-0.199158	-0.4032047	-0.321675	1.000000

Source: estimate statistician CREFAT

4.4. Long-term coefficients and short-term dynamics
4.4.a. Short-term coefficients

At the end of the results in the following table, the adjustment coefficient or force recall is statistically significant and positive, which guarantees an error-correcting mechanism, and the existence of a long-term relationship (cointegration) between the variables.

Table 4: Short Term Coefficient Estimation Results

Dependent variable : LGDP

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLKTIC(-1)	0.489749	0.143412	3.414972	0.0033
DLKHTIC	-0.000419	0.058911	-0.007115	0.9944
DLKHUM	-0.178986	0.173025	-1.034449	0.3154
DLKHUM(-1)	-0.224161	0.152963	-1.465457	0.1610
DLKHUM(-2)	0.360247	0.161845	2.225876	0.0398
DLTRAV	0.152767	0.888585	0.171922	0.8655
DL GPF	0.000117	4.79E-05	2.432826	0.0263
ERREUR(-1)	1.883136	0.570485	3.300941	0.0042

C	0.063686	0.035215	1.808508	0.0882

Source: estimate statistician CREFAT

However, technology capital, human capital, labor power and total factor productivity all have a positive effect on economic growth. For an increase in technological capital of 1% of GDP, accelerates economic growth to 0.48% in the short term. These effects act in a certain way, given the investment policy that Senegal has undertaken in recent years through the Emerging Senegal Plan (SPE) program. On the other hand, the non-ICT capital variable does not show the expected short-term effects, which is a drag on economic growth in Senegal following the study period.

Therefore, the effects of these variables represent an opportunity to integrate the transition component of investment policies into digital technology, with the aim of stimulating economic growth in Senegal.

4.4.b. Long-term coefficients

This table (8) below, informs us that long-term coefficients or elasticities have been estimated, in the same way that in the short term, almost all the variables tested remain positive. Consequently, in the long term, all the variables tested meet the criteria of significance and positivities. For technology capital, a 1% increase in GDP increases economic growth by 0.67% over the long term.

Table 5: Results of estimation of long-term coefficients

Dependent variable : LGDP

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LKTIC	0.676425	0.099369	6.807210	0.0000
LKHTIC	0.175497	0.049660	3.533999	0.0030
LKHUM	-0.489015	0.206240	-2.371099	0.0316
LTRAV	0.803459	0.275651	2.914768	0.0107
LGPF	0.000299	5.94E-05	5.037961	0.0001
ERREUR (-1)	-1.902653	0.495554	-3.839444	0.0016
C	-11.81275	2.920762	-4.044407	0.0011

Source: estimate statistician CREFAT

In sum, the results of the Auto-Regressive Distributed Lag (ARDL) model estimates concomitantly highlight the positive and decisive role of the Senegalese economy's sustainability through a transition through Information and Communication Technologies (ICTs), in Senegal. The different variables used play an important role in economic growth. Indeed, the results show that there is a positive and significant impact of information and communication technologies on economic growth. These results also explain the productive nature of investment and factor productivity.

5. Conclusions & recommendation

This article aims to analyze the sustainability of the Senegalese economy towards a digital transition. To achieve this goal, we used the ARDL (Auto-Regressive Distributed Lag) model to model the long-term and short-term dynamics of the impact of digital technologies on economic growth. In addition, this has led to the expected results.

The results of the estimates through the regression models support the research hypothesis, since they essentially show the productive traits, in terms of investment and productivity. In addition, the results of the study showed the importance of increasing the investment and productivity of digital technologies in the producing sectors, to boost supply and domestic demand. The analysis also reveals the existence of a correlation between the branches that cover the different sectors of this new economy in Senegal.

However, the analysis indicates the existence of a positive and significant effect of the digital on the economic activity, thus a possibility of transition. This is why we suggest, the implications of economic policies in the sector. First and foremost, the State should promote and reinforce investment (in capital and human resources) and innovation, particularly through the establishment of major ecosystems performing well in the telecommunications sector, technologies of the information, digital services, research & development (R & D) and human capital formation. Secondly, training and real capacity building and digital technology ownership would make better use of exchange and transfer in terms of agreement and technology cooperation.

In addition, the State should also conduct policies of strengthening and protection in terms of taxation of technological capital, in order to boost the productivity of products and services of digital technologies.

The state should likewise continue efforts to create a business-friendly business environment for Small and Medium Enterprises (SME) and startups operating in the digital sector.

The State should also accelerate the creation of industrial parks to enable local companies and startups to increase their productivities and distribution of digital services and content in order to boost its share in the gross domestic product.

And finally, to give more resources to the actors of the sector, which contributes to and facilitates the access and control of structures in charge of digital technologies in Senegal.

6. Bibliographical references

[1] Acemoglu. D (2003). *"L'abor and Capital Augmenting Technical Change", Journal of European* economic.

[2] Autorité de Régulation des Télécommunications et des Postes (ARTP, 2017), Rapport, sur le marché des Télécommunications au Sénégal, Décembre, 2017.

[3] Diop M. B (2017) « *Quels secteurs pour quelle croissance économique au Sénégal ?* ». Direction de la Prévision et des Etudes Economiques (DPEE), Ministère de l'Economie et des Finances, Sénégal.

[4] Direction de la Prévision et des Etudes Economique (DPEE, 2017), « *Rapport, situation économique et financière du Sénégal* », Décembre 2017.

[5] Direction de la Prévision et des Etudes Economique (DPEE, 2017), « Rapport, situation économique et financière », Décembre 2017.

[6] D'souza C et Williams D (2017). "*l'économie numérique*". Revuee de la banque du Canada. Département des analyses de l'économie canadienne.

[7] Gille. L (2009) « *les Dilemmes de l'économie numérique* », *FYP Edition*, 2009 .

[8] Gordon R J. (2015). « *Secular Stagnation: A Supply-Side View* », *The American Economic Review,* vol. 105, n° 5, p. 54-59..

[9] Hulten C. R, (2001). « *Total factor productivity: A short biography* », dans hulten,, Dean et Harper (edition), New Developments in Productivity Analysis, University of Chicago Press pour National Bureau of Economic Research.

[10] Kuma .J. k. (2018). "*Modélisation ARDL, test de cointégration aux bornes et application de Toda-Yamamoto : éléments de théorie et pratique sur logiciels*" HAL Id: cel-01766214https://hal.archives-ouvertes.fr/cel-01766214.

[11] Pesaran, M.H. et Pesaran, B. (1997), « *Working with microfit 4.0: Interactive econometric analysis* », Oxford, Oxford University Press**.**

[12] Pesaran M.H., Shin Y. et Smith R.J. (2001), « *Bounds Testing Approaches to the Analysis of Level Relationships* », in Journal of Applied Econometrics, Vol.16, n°3, pp. 289-326 (http://dx.doi.org/10.1002/jae.616).

[13] Pesaran, M.H. et Shin, Y. (1998), « *An Autoregressive Distributed-Lag Modelling Approach to Cointegration Analysis* », Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium, Vol.31, pp. 371-413 (http://dx.doi.org/10.1017/CCOL0521633230.011).

[14] _____(1999), « *An autoregressive distributed lag modelling approach to cointegration analysis* », Econometrics and Economic Theory in the 20th Century : the Ragnar Frisch Centennial Symposium. Cambridge Univ. Press, Cambridge, pp. 1-31.

[15] Phillips Perron C. (1987), « *Time Series Regression with a Unit Root* », in Econometrica, vol.55, No.2, March, pp. 277-301 (http://www.jstor.org).

[16] _____(1991), « *Optimal Inference in Cointegrated Systems* », in Econometrica, Vol.59, pp. 283-306.

[17] Phillips, P. C. B. et Durlauf, S. N. (1986), « *Multiple Time Series Regression with Integrated Processes* », in Review of Economic Studies, Vol.53, pp. 473-495.

[18] Phillips, P. C. B. et Ouliaris, S. (1990), *« Asymptotic Properties of Residual BasedTests for Cointegration »*, in Econometrica, Vol.58, pp. 165-193.

[19] Phillips, P. et Perron, P. (1988), « *Testing for a Unit Root in Time Series Regression* », in Biometrica, Vol.75, pp. 335-46. Lien: http://dx.doi.org/10.1093/biomet/75.2.335.

[20] Varian, H. (2016). « *Intelligent Technology* », Finance and Development, vol. 53, n° 3, p. 6-9**.**