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Impact of physical infrastructures on agricultural production in Burundi

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Abstract - The main objective of this article is to explore the impact of physical infrastructures on agricultural production in Burundi. We use the Engle-Granger method to estimate quarterly data from 2005q1 to 2020q4. First, the results revealed that all series under study are integrated of order one (ADF unit root test) and cointegrated (Engle-Granger cointegration test). Secondly, the OLS results show that in the long term, electricity, and water/sanitation infrastructures considerably contribute to agricultural production, while ICTs influence agricultural production less. Furthermore, transport infrastructure does not affect immediately agricultural production. Thirdly, the results of the ECM reveal that in the short term, ICTs occupy an important place in improving agricultural production, water/sanitation infrastructures have no impact, and transport infrastructures have a negative and significant impact on agricultural production. These results have policy implications that would enable Burundian government decision-makers to adopt strategies aimed at increasing the resources allocated to basic physical infrastructures, in particular the electricity and water/sanitation sectors, as well as to improve their offer.

Index Terms - Impact ; physical infrastructures ; agricultural production ; Engle-Granger method ; Burundi.

I. INTRODUCTION

Physical infrastructures remain a major priority for all economic sectors. Building resilient, reliable and sustainable infrastructure is one of the elements of the ninth SDG to promote economic growth [1]. Physical infrastructure has both direct and indirect effects on agricultural productivity. Physical infrastructure may be divided into two groups: (a) water and sanitation sectors and (b) other sectors, e.g. irrigation, energy, telecommunications and transportation. The water and sanitation sectors improve the health conditions of rural populations and their productivity, and the second group (irrigation, energy, telecommunications and transportation sectors) create more possibilities in terms of production [2,3,4].

Theoretically, in economic thought, the concept of infrastructure finds its origin in the Marxist theory according to which it is defined as the set of productive forces that constitute the material base and it has no meaning without being associated with the superstructure [5]. Soon after, development economists [6,7,8] emerged from analyzing the link between infrastructure and development. Indeed, the evolution of the infrastructure is relative to the development of endogenous growth theory [5]. Endogenous growth theorists give a vital place to public infrastructures in economic growth [9] in particular the theorist Barro 1990.

Empirically, the available evidence shows that in African countries, physical infrastructures make a mixed contribution to increased agricultural production. As found by Oyelami et al. [10] and Ighodaro [11], ICT infrastructures influence in a positive and significant way the growth of agricultural production in 39 sub-Saharan countries and in Nigeria. Similarly, access to the road network increases agricultural production in Ethiopia [12]. On the other hand, the electricity infrastructures have only a negative and insignificant effect on the agricultural sector in Togo [13] but, they significantly negatively influence the agricultural production in Nigeria [11].

In developing countries like Burundi, physical infrastructures are essential for the development of agriculture, the mainstay of its economy. In this country, the supply of electricity and water is monopolized by the State. In Burundi, more than 91.2 % of the populations are rural and their access to the various basic infrastructures is limited because of the low density of these infrastructures in the rural area and the high purchase cost. According to the action plan for infrastructures in Burundi, about 3 % of the population have access to telephone networks and the Internet, barely 2 % to electricity, a small proportion of rural people have access to paved roads and those having access drinking water and sanitation remains comparable to the situation in other low-income countries [14].

From 2005-2017, the Burundian Government increased spending (from 1,143,721,179 BIF to 3,771,462,601 BIF) [15] for the development of basic physical infrastructures. Despite this increase, between 2005 and 2022, the development of physical infrastructures remain low. This is induced by a slight increase in the density of water and sanitation infrastructures (from 56.12 to 68.11), ICT (from 0 to 6.81), electricity production (from 0.26 to 0.34) and decrease in the density of road networks (from 11.62 to 8.61)) [16]. Thus, during the period from 2005 to 2020, agricultural production in index increased slightly by 204.92 (from 923.08 to 1123) [17], which may hamper the economy of this country.

According to the empirical evidence above, no work has assessed the impact of physical infrastructure by considering four components of physical infrastructure at the same time, namely electricity, transport, ICT , water and/or sanitation. Moreover, to our knowledge, no study has been carried out on Burundi. For these reasons, our article focuses on Burundi by simultaneously using the four types of physical infrastructure to verify whether these infrastructures constitute a tool for agricultural development in Burundi.

II. LITERATURE SURVEY

II.1. Theoretical link between physical infrastructure and agricultural production

Endogenous growth theorists place public infrastructure at the heart of long-term economic growth. Barro 1990 integrates public expenditure into his model as a tool for economic growth [18]. Subsequently, Futagami et al. [19] extended Barro’s model by integrating in addition to public capital, private capital that Barro 1990 was unaware of its existence in infrastructure financing while positing from the outset that part of the total capital must be public. Compared to its predecessors, Barro’s model 1990 involves infrastructures directly in the growth process. Physical infrastructures contribute to the development of agriculture through various channels such as the energy, ICT, transport, water and sanitation sectors.

Developed road networks can indirectly affect agricultural productivity by facilitating access to financial institutions of farming loans, better health hospitals and agricultural training centers [20]. Water and sanitation improvements primarily affect people's overall health [21]. Good physical condition and good health in an adult are the factors for improving agricultural performance [22]. According to the recent FAO report, ICT tools provide relevant information and technologies related to agricultural development [23]. In rural areas, electricity allows farmers to improve irrigation facilities and intensify the areas to be irrigated and consequently increasing crop production [24].

II.2. Empirical link between physical infrastructure and agricultural production

In sub-Saharan countries, ICT infrastructure contributes more to improving agricultural production. Oyelami et al. [10] considered panel data on 39 sub-Saharan countries for the period 1995-2017. In support of Using the ARDL method, they found that ICTs have positive and significant externalities on the performance of the agricultural sector in the long run as well only in the short term. Antle's approach was used to estimate panel data from 2000-2011 for 34 African countries. The results confirm that ICTs contribute in general to the improvement of agricultural production [25]. By applying Hendry's method, Ighodaro [11] discovered that in Nigeria, ICTs affect agricultural production in a positive and significant way.

Regarding energy infrastructure, its contribution to the agricultural sector is mixed depending on the continent. On the African continent, the energy infrastructure negatively affects the agricultural sector. In support of the results from the maximum likelihood and Granger causality method,[13] reports that in Togo, the electricity sector only has a negative and insignificant effect in the agricultural sector long-term. Conversely, by applying different methods than that of their predecessor, they came to divergent conclusions. Ighodaro [11] did his work in Nigeria over the period from 1960 to 2004 using the Hendry method. In this country, period-lagged electricity has a negatively significant relationship with current agricultural production.

Moreover, in Asian countries, the impact of the electricity sector on the growth of agricultural production is divergent. Estimates of the ARDL technique revealed that energy consumption in Pakistan plays an important role in the agricultural sector compared to other sectors [26]. By adopting the same technique, Chandio et al. [27] confirm that gas and electricity consumption in Pakistan have positively and significantly contributed to agricultural economic growth in the long-term and short-term over the period of 1984-2016. Thus, the analyzes made in the 256 Indian districts thanks to the multivariate and univariate methods allowed Narayanamoorthy and Hanjra [20] to conclude that rural electrification has no significant influence on agricultural production in India.

Indeed, road infrastructures are important in Africa as well as in Asia. A study conducted in Ethiopia to explore the causal effect of both road networks and access to economic development extension used the general difference-in-differences technique. The results after the estimates show that access to the road network increases agricultural production by 11% [12]. Similarly, Narayanamoorthy and Hanjra [20] pointed out that roads significantly influence agricultural production in India.

III. METHODOLOGICAL FRAMEWORK

III.1. Data sources and variables used

III.1.1. Data sources

The time series data covering the period from 2005 to 2020 comes from two sources, namely the site of the Africa Infrastructure Development Index [16]; and Food and Agricultural Organization Statistics [17]. We extracted data from the series gross agricultural production index on FAOSTAT and other series namely water and sanitation composite index, information, and communication technology composite index (ICT), electricity composite index and transport composite index on AIDI.

III.1.2. Description of the variables

Agricultural production can be measured through a dimension called the agricultural production index [28]. In this article, tis index (the reference year 2014-2016) is defined as the whole gross crop production index (primary vegetables and fruits, roots and tubers, oilseeds, primary textures, raw sugar crops, cereals, soybeans, cotton not shelled and unshelled groundnuts) and the gross animal production index (livestock, milk, and indigenous meat) [17]. Based on the work of Lamine and Modibo [29], we use physical infrastructure stocks as an approximation of physical infrastructure which is composed of four dimensions namely water and sanitation infrastructure (wtsn), electricity (elct), ICT and transport (trsp). Indeed, the description of the variables selected are summarized in Table 1.

Variables	Descriptions	Expected effects	Source
prod:	Gross agricultural production index	+	*FAOSTAT (2022)*
trsp:	Transport Composite index (total length of paved roads in km per 10,000 inhabitants and density of the road network in km per km ^{2} of usable area)	+	*AIDI (2022)*
elct:	Electricity index (in millions of kilowatt hours produced per hour and per capita)	±	*AIDI (2022)*
wtsn:	Water and Sanitation Composite Index (percentage of the population with access to an improved water source and the percentage of the population with access to improved sanitation facilities)	+	*AIDI (2022)*
TIC:	ICT composite index (total number of telephone subscribers (per 100 inhabitants), total number of internet users (per 100 inhabitants), fixed broadband internet subscribers (per 100 inhabitants), broadband connectivity international band (Mbps))	+	*AIDI (2022)*

Table 1: Description of variables included in the model

III. 2. Data analysis method

III.2.1. Model Specification

This article adopts the Cobb-Douglas production function approach. In addition, economic modeling of the effects of infrastructure on growth refers to new theories of endogenous growth. So we rely on the framework of Barro 1990 but with some modifications like usage inventory of physical infrastructure. This model integrates into the production function the infrastructure flows or public expenditure flows [30,31] which play the same role as capital and labor. So, in this article, agricultural production is a function of transport, electricity, water/sanitation, as well as ICT, which makes it possible to write as follows :

$$\mathrm{prod_t} = \mathrm{f(Atrsp, elct, wtsn, ICT)}, \qquad (1)$$

$$\Leftrightarrow \mathrm{prod_t} = \mathrm{Atrsp_t^{\alpha_1} elct_t^{\alpha_2} wtsn_t^{\alpha_3} ICT_t^{\alpha_4}}, \qquad (2)$$

By proceeding to the linearization of (2) by the logarithmic function, we find:

$$\mathrm{ln\_prod_t} = \mathrm{ln\_A} + \alpha_1 \mathrm{ln\_trsp_t} + \alpha_2 \mathrm{ln\_elct_t} + \alpha_3 \mathrm{ln\_wtsn_t} + \alpha_4 \mathrm{ln\_ICT_t} + \varepsilon_t$$

$$\mathrm{ln\_prod_t} = \alpha_0 + \alpha_1 \mathrm{ln\_trsp_t} + \alpha_2 \mathrm{ln\_elct_t} + \alpha_3 \mathrm{ln\_wtsn_t} + \alpha_4 \mathrm{ln\_ICT_t} + \varepsilon_t, \qquad (3)$$

Where $\alpha_0 = \mathrm{ln\_A}$ is a constant; $\mathrm{ln\_prod_t, ln\_trsp_t, ln\_elct_t, ln\_wtsn_t}$ and $\mathrm{ln\_ICT_t}$ are natural logarithm times series. Before estimating model (3), we first checked the stationarity of the considered series, then the existence of cointegration. This allowed us to adopt the two-step estimation method (Engle-Granger error-correction model). According to the econometric literature, this model is appropriate when the series under study are both integrated of order one and cointegrated [32].

III.2.2. Engle–Granger method

The Engle-Granger method is performed in two steps. In the first step, we check if the variables under study are all non-stationary in level (i.e. integrated of order one). Once confirmed, we proceed to the cointegration test. From the perspective of Engle-Granger, it consists in estimating the model (3) by the method of ordinary least squares (OLS), which gives:

$$\widehat{\mathrm{ln\_prod}}_t = \widehat{\alpha_0} + \widehat{\alpha_1} \mathrm{ln\_trsp_t} + \widehat{\alpha_2} \mathrm{ln\_elct_t} + \widehat{\alpha_3} \mathrm{ln\_wtsn_t} + \widehat{\alpha_4} \mathrm{ln\_ICT_t}, \quad (4)$$

Therefore, we can calculate the estimated residuals : $\widehat{\varepsilon_t} = \mathrm{ln\_prod_t} - \widehat{\mathrm{ln\_prod}}_t$.

In the second step, on the estimated residuals, we proceed to the unit root test. Considering the simple Dicker-Fuller test, this assumes that $\widehat{\varepsilon_t} = \rho\hat{\varepsilon}_{t-1} + \nu_t$ In this case, we perform the following test:

$$\mathrm{H_0}: \rho = 1 \text{ versus } \mathrm{H_1}: \rho < 1$$

$$\mathrm{H_0}: \text{Stationarity versus } \mathrm{H_1}: \text{non} - \text{stationary}$$

If the null hypothesis is not rejected, there is no cointegration. Conversely, if the null hypothesis is rejected, there is cointegration. In this case, we have to do the modeling in the form of an error correction model (ECM), which is the canonical representation of cointegrated series. It then takes the following form:

$$\Delta(\mathrm{ln\_prod_t}) = \alpha + \gamma\hat{\varepsilon}_{t-1} + \delta_1\Delta(\mathrm{ln\_prod_{t-1}}) + \delta_2\Delta(\mathrm{ln\_Atrsp_{t-1}}) + \delta_3\Delta(\mathrm{ln\_elct_{t-1}}) + \delta_4\Delta(\mathrm{ln\_wtsn_{t-1}}) + \delta_5\Delta(\mathrm{ln\_ICT_{t-1}}) + \nu_t, \qquad (\mathbf{5})$$

Where γ represents the coefficient associated with the restoring force which must be less than unity and negatively significant, Δ represents the first difference operator.

IV. RESULTS AND DISCUSSIONS

IV.1. Descriptive statistics

According to Table 2, agricultural production is on average 6.98 with a maximum of 7.17 and a minimum of 6.77, i.e. a range of growth in agricultural production of 0.4. This production is obtained by using an average of 2.23 the transport composite index, less than 1.50 electricity composite index, 4.11 water and sanitation composite index and less than 1.78 ICT composite index. Thus, the standard deviations for all the series considered are less than one except for ICT. This means that the index series for agricultural production, transport, electricity, water and sanitation have deviated from the average by 0.09, 0.10, 0.26 and 0.05. Moreover, the series agricultural production, electricity, water and sanitation are normally distributed because the Jarque-Bera probabilities for these variables are greater than 5%.

Variables	ln_prod	ln_trsp	ln_elct	ln_wtsn	ln_ICT
Mean	6.98	2.23	-1.50	4.11	-1.78
Maximum	7.17	2.48	-0.86	4.20	1.73
Minimum	6.77	2.15	-1.92	4.02	-8.18
Skewness	0.26	1.13	0.32	-0.06	-0.70
Kurtosis	2.25	3.21	2.77	1.76	1.84
Std. Dev.	0.09	0.10	0.26	0.05	3.59
Jarque Bera	2.13	13.34	1.26	4.00	8.59
Probability	0.343	0.001	0.532	0.134	0.014
Observations	62	62	62	62	62

Table 2- Descriptive statistics of the series used

IV.2. Unit root test results

All stationarity tests via ADF are done at the 5 % threshold. Therefore, the results shown in Table 3 allow us to accept the hypothesis of a unit root in level (non-stationarity) for all series because the probability values are greater than 5 %. Therefore, we proceed to the differentiation procedure. Therefore, the probability values for all the series are less than 5%, which implies that these series are integrated of order one, i.e. stationary in the first difference.

Series		ADF Test		Remark
	Model	Level	First difference	
ln_prod	Constant	-2.1133 (0.2403)	-4.4762*** (0.0006)	I(1)
	trend and constant	-3.2396 (0.0864)		
ln_trsp	Constant	-2.7047 (0.0790)	-4.4019*** (0.0007)	I(1)
	Trend and constant	-2.4073 (0.3724)		
ln_elct	Constant	-1.6009 (0.4757)	-3.7656** (0.0054)	I(1)
	Trend and constant	-2.4034 (0.3740)		
ln_wtsn	Constant	-0.7751 (0.8190)	-4.2905** (0.0011)	I(1)
	Trend and constant	-1.7913 (0.6971)		
ln_ ICT	Constant	-1.8165 (0.3691)	-6.3541*** (0.0000)	I(1)
	Trend and constant	-0.5231 (0.9797)		

Table 3- Augmented Dickey-Fuller Test for stationarity

IV.3. Cointegration test

The cointegration tests proposed in the literature to verify the equilibrium relationship between the series are that of Engle-Granger 1987, Johansen 1988 [33] and Pesaran et al. 2001 [34]. In our case, the series selected fulfill the necessary condition for the use of the Engle-Granger test (the series are all integrated of order one). The results of the residue test are reported in Table 4.

Residue	ADF Test		Order integration
	Statistics (.)	5% CV	
ECT	-3.5138* (0.0117)	-2.9238	I (0)

Table 4- Augmented Dickey-Fuller Test on residue at level

The values of the ADF statistical test show that the residual is stationary in level. Consequently, the ln_prod, ln_trsp, ln_elct, ln_wtsn and ln_ICT series are cointegrated at the 5% threshold. Therefore, it is possible to estimate the error correction model (ECM).

IV. 4. Results of the Engle-Granger method

We estimated the long-term relationship between the variables under study using the ordinary least squares (OLS) method. The results presented in Table 5 show that in the long term, the elasticity of transport infrastructure is not significant. This means that transport networks in Burundi play minor role in the growth of agricultural production. Our conclusion contradicts those of Narayanamoorthy and Hanjra [20] who emphasize that in the long-term transport infrastructure contributes positively and significantly to the improvement of agricultural production.

Thus, the elasticity of electricity infrastructure (0.0635) is simply significant at the 5 % level. This means that 1 % of changes in electricity infrastructure increase agricultural production by 0.0635 % in the long term, all other things being equal. Various studies [27, 26] find the same conclusions. Conversely, the work of Narayanamoorthy and Hanjra [20] indicates that energy does not significantly affect agricultural production in the long term. In addition, electricity consumption does not significantly affect the agricultural production [13].

An estimated coefficient (2.5737) of water and sanitation infrastructure is very higher significant at the 1 % level. That means when the water and sanitation infrastructure increased by 1 %, it will boost the agricultural production in Burundi by 2.5737 % in the long term, ceteris paribus. In the long term, the ICT influences very higher significantly and negatively the agricultural production in Burundi at 1 % level. This means if ICT increases by 1 % in the long term, the agricultural production in Burundi decreases by 0.0244 %, ceteris paribus. Conversely, Lamine and Modibo [29] found that the ICT did not significantly influence the agricultural production in Mali. Additionally, in the long term, Oyelami et al. [10] and Ighodaro [11] found that in Sub-Saharan Africa and in Nigeria, the ICT contributed positively and significantly to the growth of agricultural production.

The second step of the Engle-Granger model is to estimate the coefficients of the error correction model. According to table 6, the value of the coefficient associated with the restoring force (-0.152) is negative and higher significant at the 5 % level. This value indicates that 15.2 % of the imbalance of the given period (t-1) is corrected in the following period (t). In the long term, the imbalance between agricultural production and physical infrastructure (transport, ICT, electricity, water/sanitation) compensates for each other so, that these five series have similar evolutions. In addition, the shock occurred for one year is absorbed after approximately six years and six months (1/0.152 = 6.58 years).

The short-term elasticity associated with transport infrastructure (-1.6450) is negative and very higher significant at the 1 % level. This means that if the transport infrastructure increases by 1%, the agricultural production in Burundi decreases by 1.6450 % in the short term, ceteris paribus. The results of Lamine and Modibo [29] and Narayanamoorthy and Hanjra [20] show that in the short term, the transport infrastructure influence positively and significantly the agricultural production.

The coefficient of ICT in the short term (0.0633) is positive and very higher significant at the 1 % level. This means that when the ICT increases by 1 % in the short term, the agricultural production is boosted by 0.0633 %, ceteris paribus. Similarly, the results of

Oyelami et al. [10] and Ighodaro [11] reached to the same finds. Conversely, the results of Lamine and Modibo [29] reveal that ICT has no significant effect on GDP per capita in short-term.

In Burundi, the electricity and water/sanitation infrastructures are not significant at 5 % level in the short-term. On the other hand, Chandio et al. [27] found that the electricity consumption positively influences agricultural production in the short term.

The value of R-squared (0.7412) reveals that 74 % of fluctuations in current agricultural production are explained by the physical infrastructures of the previous period. Also, the errors are uncorrelated because the value of Durbin-Watson (2.24) is between 2 and 4-d_{sup}, the area of the no correlation. The F-statistic (13,47) of the error correction model is very higher significant at 1 % level.

Dependent variable: Δ(ln_prod)				
Variables	Coefficient	Std. Error	t-statistic	Prob.
Long-term coefficients via the OLS				
ln_trsp	-0.1831	0.1727	-1.0598	0.2937
ln_elct	0.0635*	0.0280	2.2651	0.0273
ln_wtsn	2.5737***	0.3456	7.4465	0.0000
ln_ICT	-0.0244***	0.0068	-3.5817	0.0007
Cons	-3.1462*	1.5153	-2.0763	0.0424
Short-term dynamics via the ECM				
Cons	-0.0539	0.0377	-1.4323	0.1587
Δ(ln_trsp)	-1.6450***	0.2608	-6.3066	0.0000
Δ(ln_elct)	0.0479	0.0270	1.7746	0.0824
Δ(ln_wtsn)	20.1823	15,238	1.3245	0.1917
Δ(ln_ICT)	0.0633***	0.0176	3.5956	0.0008
Δ(ln_trsp(-1))	1.4837***	0.3002	4.9418	0.0000
Δ(ln_elct(-1))	-0.0033	0.0296	-0.1116	0.9116
Δ(ln_wtsn (-1))	-2.1050	14,972	-0.1406	0.8888
Δ(ln_ICT(-1))	-0.0362**	0.0121	-2.9882	0.0045
Δ(ln_prod(-1))	0.6116***	0.0830	7.3652	0.0000
ECT (-1)	-0.1518**	0.0547	-2.7761	0.0079
R-squared		0.7412		
Durbin-Watson		2.24		
F-Statistic		13,465		
Prob(F-Statistic)		0.0000		

Table 5-OLS and ECM coefficients

IV.4.1. Diagnostic tests

According to table 6, the probabilities of the tests carried out are greater than 5 %. That means the errors are uncorrelated (Breusch-Godfrey test), homocedastic (Breusch-Pagan-Godfrey test, ARCH test) and, the model is well specified (Ramsey test).

Hypotheses	Tests		Values (Prob.)
H_0 : Uncorrelated errors H_1 : Correlated errors	Breusch-Godfrey	F-statistic	0.6499 (0.5269)
		Obs*R-squared	1.6284 (0.4430)
H_0 : Homocedastic errors H_1 : Heteroscedastic errors	Breusch-Pagan-Godfrey	F-statistic	0.3042 (0.9765)
		Obs*R-squared	3.5256 (0.9662)
	ARCH	F-statistic	0.0002 (0.9898)
		Obs*R-squared	0.0002 (0.9896)
H_0 : Well-specified model H_1 : Model incorrectly specified	Ramsey RESET	F-statistic	0.0075 (0.9314)
		Likelihood ratio	0.0095 (0.9225)

Table 6- Classic tests

Furthermore, Figure 1 shows that the model is structurally stable because the Cusum statistics evolves inside the interval. However, the model is punctually unstable as shown in Figure 2. The areas of instability are 2011Q4 and from 2013Q3 to 2017Q4. Therefore, the model must be stabilized to confirm the stability hypothesis. Figure 3 shows the Cusum squared after stabilizing the model.

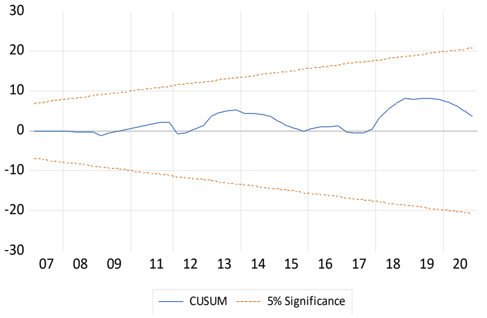

Fig.1-Cusum test

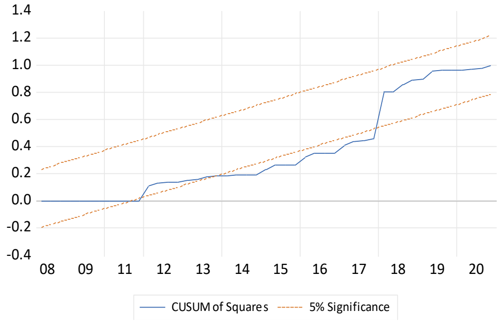

Fig.2- Cusum of squares test

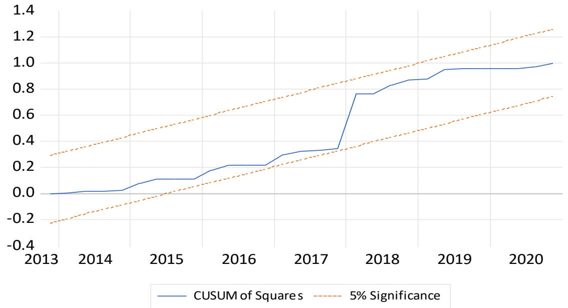

Fig.3- Cusum of squares test after model stabilization

V. CONCLUSIONS AND POLICY IMPLICATIONS

The purpose of this article is to analyze the contribution of physical infrastructures to agricultural production in Burundi. The finds of the estimation of the long-term relationship by the OLS method reveal that in Burundi, only the electricity and water/sanitation infrastructures contribute considerably to boost agricultural production. On the other hand, ICT negatively affect the agricultural production, and the transport infrastructure have not impacted the agricultural production. Moreover, in the short term the results of the error correction model (ECM) show that in the short term, ICT infrastructure plays an important role in improving agricultural production in Burundi. While the transport infrastructure negatively affects the agricultural production. The electricity and water/sanitation infrastructures have not the impact in the agricultural production.

According to ours finds, we suggest that Government policymakers should allocate significant resources to electricity and water/sanitation infrastructures to boost agricultural production.

VI. REFERENCES

[1] Nations, U. (2023). Progress towards the Sustainable Development Goals: Towards a Rescue Plan for People and Planet.

[2] de KY Amoako, P., Okouda, M. A., Nkueté, J., & Goma, L. S. (2003). L'intégration régionale en Afrique centrale. *L'intégration régionale en Afrique centrale: bilan et perspectives*.

[3] Llanto, G. M. (2012). The impact of infrastructure on agricultural productivity.

[4] Pinstrup-Andersen, P., & Shimokawa, S. (2007). Infrastructures rurales et développement agricole. *Revue d'économie du developpement*(4), 55-90.

[5] Zakane, A. (2009). L'impact des dépenses d'infrastructures sur la croissance en Algérie. Une approche en series temporelles multi variées (var). *les cahiers du cread*, *87*, 27-49.

[6] Hirschman, A. O., & Sirkin, G. (1958). Investment criteria and capital intensity once again. *The Quarterly Journal of Economics*, *72*(3), 469-471. https://doi.org/10.2307/1882237

[7] Nurkse, R. (1952). Some international aspects of the problem of economic development. *The American Economic Review*, *42*(2), 571-583.

[8] Rosenstein-Rodan, P. N. (1943). Problems of industrialisation of eastern and south-eastern Europe. *The economic journal*, *53*(210-211), 202-211. https://doi.org/10.2307/2226317

[9] Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of political economy*, *94*(5), 1002-1037.

[10] Oyelami, L. O., Sofoluwe, N. A., & Ajeigbe, O. M. (2022). ICT and agricultural sector performance: empirical evidence from sub-Saharan Africa. *Future Business Journal*, *8*(1), 1-13. https://doi.org/10.1186/s43093-022-00130-y

[11] Ighodaro, C. A. (2010). Infrastructure and agricultural growth in Nigeria. *Ethiopian Journal of Economics*, *19*(2), 147-173.

[12] Gebresilasse, M. (2023). Rural roads, agricultural extension, and productivity. *Journal of development Economics*, 103048. https://doi.org/10.1016/j.jdeveco.2023.103048

[13] Kpemoua, P. (2016). Analyse de L'impact de L'énergie électrique sur la croissance économique Du Togo.

[14] BAD. (2009). *Un plan d'action pour les infrastructures au Burundi: accélérer l'intégration régionale*.

[15] MAFAP. (2022). Monitoring and Analysing Food and Agricultural Policies. https://www.fao.org/in-action/mafap.

[16] AIDI. (2022). African Development Bank Group. http://dataportal.opendataforafrica.org/AIDI.

[17] FAOSTAT. (2022). Food and Agriculture Organization of the United Nations. https://www.fao.org/faostat/fr/#data/QI.

[18] Guellec, D., & Ralle, P. (2003). Les nouvelles théories de la croissance.

[19] Futagami, K., Morita, Y., & Shibata, A. (1993). Dynamic analysis of an endogenous growth model with public capital. *The Scandinavian Journal of Economics*, 607-625. https://doi.org/10.2307/3440914

[20] Narayanamoorthy, A., & Hanjra, M. A. (2006). Rural infrastructure and agricultural output linkages: A study of 256 Indian districts. *Indian Journal of Agricultural Economics*, *61*(902-2016-67405).

[21] Billig, P., Bendahmane, D., & Swindale, A. (1999). *Water and sanitation indicators measurement guide*: Food and Nutrition Technical Assistance Project, Academy for Educational ….

[22] Alahyane, S. (2017). La souveraineté alimentaire ou le droit des peuples à se nourrir eux-mêmes. *Politique étrangère*(3), 167-177. https://doi.org/10.3917/pe.173.0167

[23] Sylvester, G. (2017). *Success stories on information and communication technologies for agricultural and rural development*. www.fao.org/publications

[24] Ahmed, R., & Mustafa, U. (2016). Impact of CPEC projects on agriculture sector of Pakistan: Infrastructure and agricultural output linkages. *The Pakistan Development Review*, 511-527.

[25] Chavula, H. K. (2014). The role of ICTs in agricultural production in Africa. *Journal of Development and Agricultural Economics*, *6*(7), 279-289. https://doi.org/10.5897/JDAE2013.0517

[26] Murugan Nathan, T., & Wong, W.-k. (2012). Are sectoral outputs in Pakistan led by energy consumption? *Economics Bulletin*, *32*(3), 2326-2331.

[27] Chandio, A. A., Jiang, Y., & Rehman, A. (2019). Energy consumption and agricultural economic growth in Pakistan: is there a nexus? *International Journal of Energy Sector Management, 13*(3), 597-609. https://doi.org/10.1108/IJESM-08-2018-0009

[28] Adom, P. K., Djahini-Afawoubo, D. M., Mustapha, S. A., Fankem, S. G., & Rifkatu, N. (2018). Does FDI moderate the role of public R&D in accelerating agricultural production in Africa? *African Journal of Economic and Management Studies*. https://doi.org/10.1108/AJEMS-07-2017-0153

[29] Lamine, T. S. S., & Modibo, T. (2022). Infrastructures et croissance économique: cas du Mali. *International Journal of Accounting, Finance, Auditing, Management and Economics*, *3*(2-2), 118-138.

[30] Barro, R. J. (1990). Government spending in a simple model of endogenous growth. *Journal of political economy*, *98*(5, Part 2), S103-S125.

[31] Oulmakki, O. (2015). *Impact des infrastructures de transport sur la croissance économique: le cas du Maroc*. Université Montpellier; Université Moulay Ismaïl (Meknes, Maroc).

[32] Keho, M. (2017). Leçon 4: Stationnarité, Cointégration et Modèles à Correction d’Erreurs.

[33] Doucouré, F. (2008). Méthodes économétriques : Cours et travaux pratiques (éd. 5e édition). In *Edition ARIMA, Sénégal*.

[34] Kuma, J. K. (2018). Modélisation ARDL, Test de cointégration aux bornes et Approche de Toda-Yamamoto: éléments de théorie et pratiques sur logiciel.