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Infrastructure development as a driver of trade liberalization in the belt and road initiative african countries: A case study from Kenya

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ABSTRACT

Several studies have been carried out on the determinants of international trade. However, little is known about the relationship between infrastructure development and international trade in sub-Saharan African (SSA) countries in general and in Kenya in particular. This article examines the effect of infrastructure development on international trade. Thus, it concerns the analysis of Kenya's economy during the period 1980-2021.The Autoregressive and Distributed Lags (ARDL) method is employed as estimation technique and different types of infrastructures such as rail lines, paved roads and access to electricity have been highlighted. Moreover, two indicators of international trade named external trade rate and Squalli and Wilson index were employed. The results revealed that access to electricity, paved roads as well as rail lines improve Kenya's external trade rate in the long run. However, no significant relationship was found in the short run. Moreover, the robostness of the results was confirmed with the Squalli and Wilson index. Therefore, Kenya's goverment must pursue its national infrastructure development program with the support of other development partners by emphasizing the intensification of electricity, the construction of roads and railway lines. To achieve its infrastructure goals Kenya needs to develop the second phase of the Country Strategy Document.

Contribution/Originality: This study is the first that analyse the effect of infrastructure development in Kenya. Moreover, this study combine the traditional et and new measures of international trade. Finally, the african infrastructure development index was used and its components (electricity, rail lines, paved road).

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1. BACKGROUND

The African continent is emerging as a destination of choice for many development actors looking for high growth markets despite the lingering effects of the financial crisis and recession. However, it is not currently in a position to take full advantage of its benefits, the main problem being the lack of infrastructure. Infrastructure could be defined as an investment in key sectors of the economy through access to electricity, water network, gas, transport and an appropriate telecommunications system, as well as real estate, with a high capacity to improve the quality of life, provide reasonable jobs and reasonably affect the education system, bridging the gap between rural and urban discrepancies (World Bank, 2010).

Statistics from World Bank (2017) show that Sub-Saharan Africa is ranked last among all developing regions in virtually all dimensions of infrastructure development. Moreover, according to the African Development Bank

(2012), transport costs and transit times of goods along road corridors are two to three times higher in Africa than other regions of the world. For this purpose, Kenya's economy is no exception to this rule.

In 2008, Kenya launched the initiative "Kenya's Vision 2030". This ambitious long-term development plan aims to transform Kenya into a "newly industrialized, middle-income country, offering a high quality of life and a healthy environment and secured to its citizens by 2030". Access to infrastructure is one of the main pillars of this plan.

Eight years to the 2030 deadline, World Bank (2022) estimated that Kenya's current infrastructure deficit can be redressed by investing US$4 billion per year over the next ten years. Thus, the Kenyan government has challenged to attract more private investors in infrastructure projects. It has also committed to exploring new approaches to address entrenched challenges such as achieving the Sustainable Development Goal (SDG) 7 (ensure access to affordable and clean energy for all). The electricity, water and road/rail sectors should receive more investment, in line with universal access and diversification goals that will guide electricity policy and require investment of 15 billion dollars until 2022 (Financial Afrik, 2019). Therefore, a strong infrastructure potential is an undeniable asset for promoting international trade in the African continent.

In 2013, Chinese President Xi Jinping announced the implementation of what is perhaps the most ambitious investment and infrastructure program ever devised. The Belt and Road Initiative (BRI) is the boldest demonstration of China's global economic, diplomatic and strategic ambitions.

East Africa is the first link in connecting the BRI to Africa. China is building ports and maritime infrastructure to improve the road from South Asia to Kenya and Tanzania, then to the Mediterranean via Djibouti. Domestic railways are also under construction. China has notably promised to combine the BRI with the former Forum for China-Africa Cooperation, to boost African agricultural productivity and increase imports of agricultural products from Africa to China (Ehizuelen & Mitchell, 2018).

Belt and Road Initiative is a "driving force" for cooperation between China and African countries as it contributes to Africa's development. The mining, gas and oil sectors of the African continent attract a large volume of Chinese foreign direct investment (Asche & Schuller, 2008). Most of its investments in Africa involved extractive industries and related infrastructure. At the time where Africa is plagued by an infrastructure investment financing gap estimated at $50 billion per year (AFDB, 2011), the contribution of china in order to alleviate issues of energy, transport and telecommunications constitutes a boon for the beneficiary countries. In addition, Chinese investments in Africa contribute to the economic transformation of the continent and help to expand the private sector through joint ventures or backward and forward linkages and create jobs subsequently.

Stylized facts from Figure 2 show that Kenya is one of the African countries where international trade has slowed down considerably since 1980. This delay in trade can be linked to the infrastructural deficit of Kenya's countries which does not allow a structural and competitive transformation of it economy since transportation costs are one of the key factors of trade costs. This is a general observation for sub-Saharan African countries, where transport infrastructure put in place still determines the levels of their participation in regional and international trade.

Sustainable development, export growth, industrialization and urbanization are the main development objectives which are achieved through the construction of infrastructure (Kim, 2006; Rostow, 1960). Likewise, the construction of infrastructure such as ports, highways and railways helps improve the standard of living of populations. For example, access to transport infrastructure facilitates better mobility of goods and services. Improvement and accessibility reduce the cost of goods and services to markets (Aschauer, 1989; Bougheas, Demetriades, & Mamuneas, 2000; Gramlich, 1994; Lem, 2002).

Empirical work has demonstrated that protectionism significantly impacts the economic cycle (Barattieri, Cacciatore, & Ghironi, 2021). In their work, Nkemgha, Poumie, and Fotio (2022) found that the twin deficit was the cause of trade protectionism in Africa. Given the harmful consequences of trade protectionism on the economy, the World Trade Organization promotes the liberalization of trade. It is in this context that we seek to know whether the improvement of infrastructure can also promote the liberalization of trade. . The work of Chang, Kaltani, and Loayza (2009) highlighted the fact that the quality of infrastructure is a channel through which trade reforms impact economic development. On the other hand, the decline of transport infrastructure had a negative impact on exports in Chile after the 2010 earthquake. The work of Li (2014) highlighted the fact that a 10% increase in internet promotes the cross of international trade from 0.2% to 4%. He explained this result by the fact that the Internet can reduce the cost of information for traders. Similarly, Olarreaga (2016) established that hard and soft infrastructure promotes the growth of trade flows. Finally, Bailey et al. (2021) found that two countries trade more when they are more socially connected, particularly for goods. for which informational frictions can be significant..

Despite the growing literature on the determinants of international trade, little is known about the relationship between infrastructure development and international trade in sub-Saharan Africa in general and in Kenya in particular. This study presents four contributions. First, our study is specifically focused on the effect of physical infrastructure on trade liberalization. Second, we employ the classical trade openness index for the baseline results and the openness index of Squalli and Wilson (2011) to test the robustness of the results. Third, the Pooled Mean Group (PMG) estimator developed by Pesaran, Shin, and Smith (1999) is employed to estimate the international trade equation. The use of this technique lies in its multiple advantages: (i) it controls the endogeneity bias in the model, (ii) it is robust to issues of autocorrelation, heteroskedasticity of errors, and (iii) it allows provide the results of both short and long run estimates. Finally, this paper is to our knowledge the first to analyze the relationship between physical infrastructure and Kenya's foreign trade.

The remainder of this paper is structured as follows. Section two highlights the stylized facts. Section three presents the literature review. Section four sets out the methodology of the study. Section 5 presents the results while section six concludes.

2. STYLIZED FACTS

This section presents some graphs on the evolution of the key variables of our study. These include the variables of international trade as well as those of infrastructure.

A cursory look at Kenya's international trade reveals striking patterns (see Figure 1). The country's total merchandise trade volume in 2020 was $21 billion, constituting 21% of the GDP. More than 16% of this total comes from trade with China (the country's largest trading partner), followed by the EU ($2.9 billion), India ($1.8 billion) and the United Arab Emirates (UAE) ($1.2 billion). The United States (nearly $1.0 billion) is Kenya's fifth largest trading partner. Other major economic partners are Uganda and Tanzania, both in East Africa.

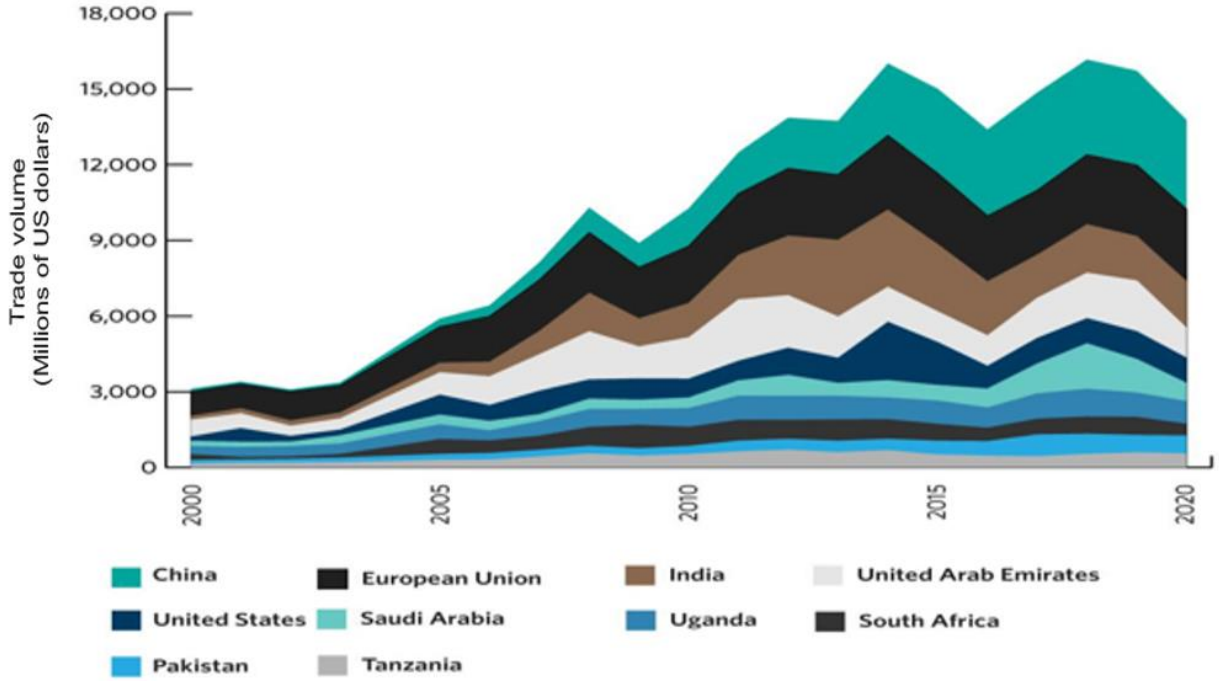

Figure 1. Trade volumes between Kenya and its top trading.

Source: Statistics (2021).

Although Kenya trades with all partners in the rest of the world, Figure 2 shows the decline in its foreign trade for more than two decades.

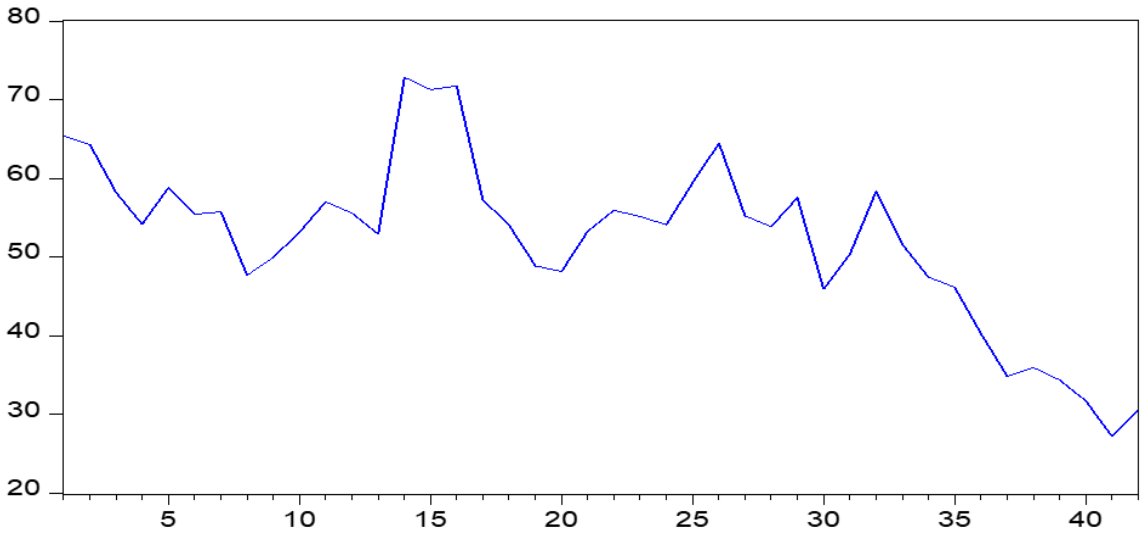

Figure 2. Evolution of Kenya's foreign trade from 1980 to 2021.

This slowdown in Kenya's foreign trade is not only due to the drop in its exports but also to the drop in its imports as shown in Figure 3.

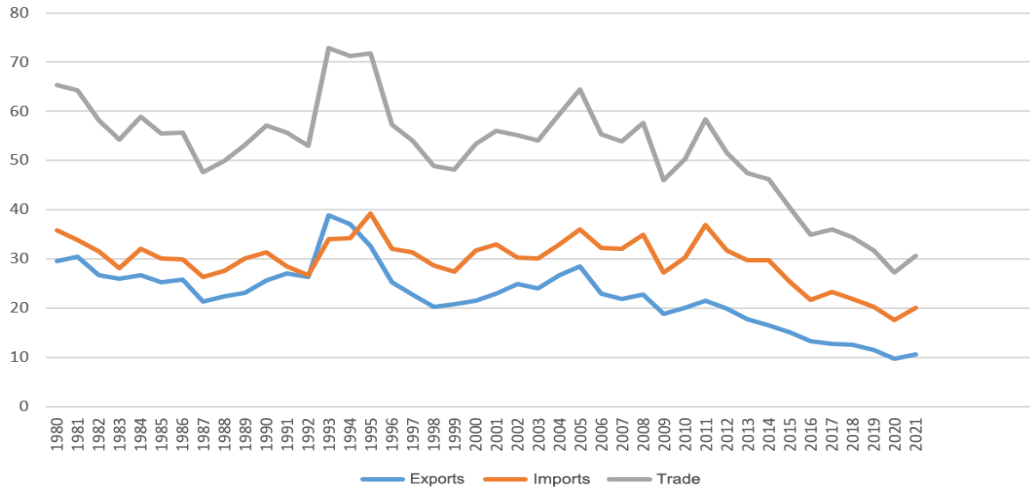

Figure 3. Evolution of Kenya's trade components between 1980 and 2021.

Analysis of Figure 3 also reveals that in general, Kenya's exports have always been lower than its imports. Consequently, the trade of this country has always been structurally in deficit as shown by the evolution of the trade balance (Figure 4).

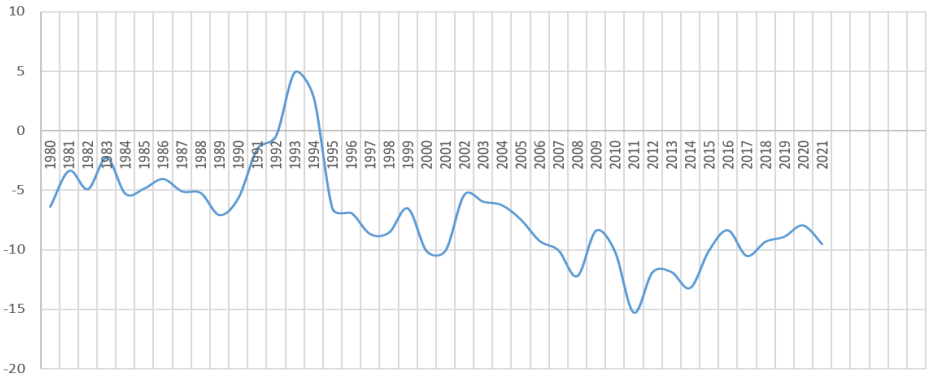

Figure 4. Evolution of Kenya's trade balance from 1980 to 2021.

Apart from Uganda, Pakistan and Tanzania, Kenya's trade balance is structurally in deficit with the other main trading partners in the world for more than two decades (see Figure 5) .With its GDP of $110.3 billion in 2021, it is the largest economy and the main driver of the rapid integration of the East African Community (EAC). It will be crucial for Kenya to balance its complex and overlapping relationships with major powers, its trade ties with its EAC neighbours and its interest in advancing the African Continental Free Trade Area. However, the country's total trade deficit in 2020 is about $9.7 billion, and China ($3.3 billion) accounts for about a third of this imbalance (Zainab & Aline, 2022).

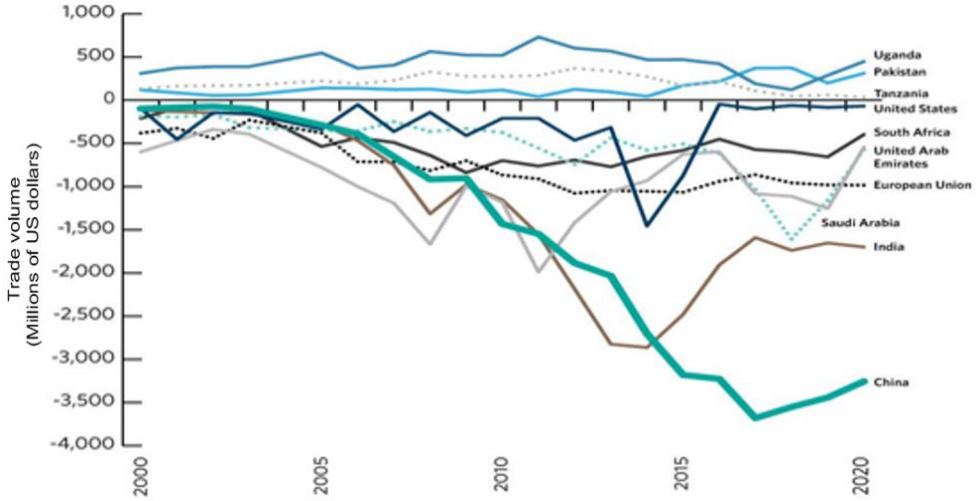

Figure 5. Kenya's trade balance with its top trading partners.

Source: Statistics (2021).

In summary, Kenya's foreign trade is not healthy. Once this observation is made, it is important to analyse the factors likely to boost it, because they constitute a source for the economic prosperity of nations according to the classic theory of international trade. Among the potential factors that contribute to improving trade, infrastructure is highlighted in the international trade literature.

Regarding the development of infrastructure, three available indicators are used in this work: rail lines, paved roads and access to electricity. These three indicators are all physical infrastructure proxies.

Figure 6 shows the evolution of railway lines in Kenya from 1980 to 2021. It is important to specify that the railway lines had been built before independence by Great Britain. Initially, the aim of this building was not only to connect the capitals which were under their control but also to promote the transportation of raw materials from production areas to the ports. With the advent of independence in 1963, the maintenance works of these lines did not follow. This is how, over time, they deteriorated and some lines were put on hold. This old railway could not meet the development needs of the port of Mombasa. As the largest port in East Africa, Mombasa is connected to 80 ports around the world through 17 international shipping lines. Most goods enter or leave East Africa through this port. Due to insufficient transport capacity via the railway, goods were mostly transported by road. The saturation of road transport and the overcrowding of goods in the port were to some extent detrimental to the development of Mombasa and even that of Kenya. These difficulties have led the Kenyan government not only to maintain the existing lines but also to launch other extension works, one of the most recent being the modernization of the line linking Nairobi to Mombasa, which was delivered in 2017.

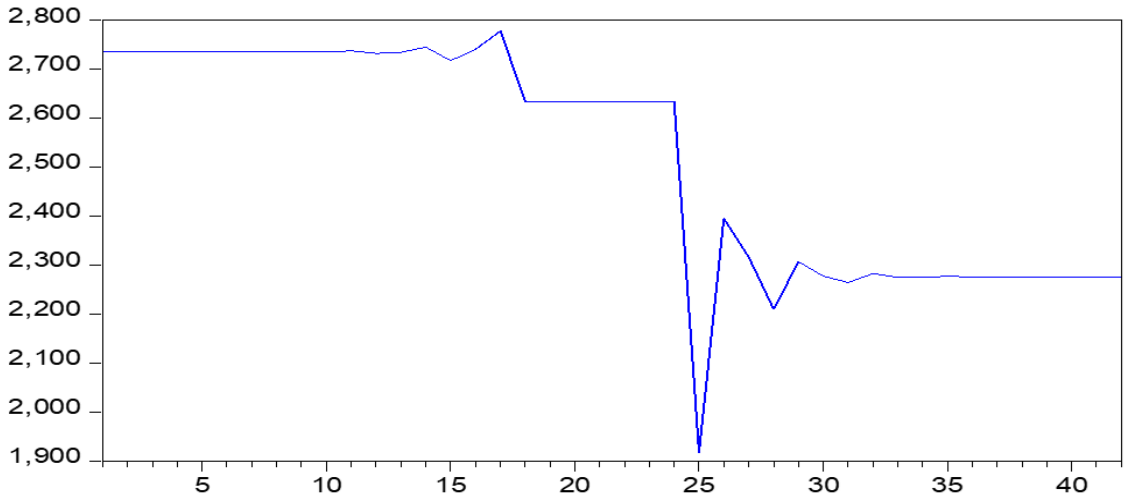

Figure 6. Evolution of rail lines in Kenya from 1980 to 2021.

As for the paved roads, it regresses over time as shown in Figure 7. This figure also reveals that the roads are not as healthy.

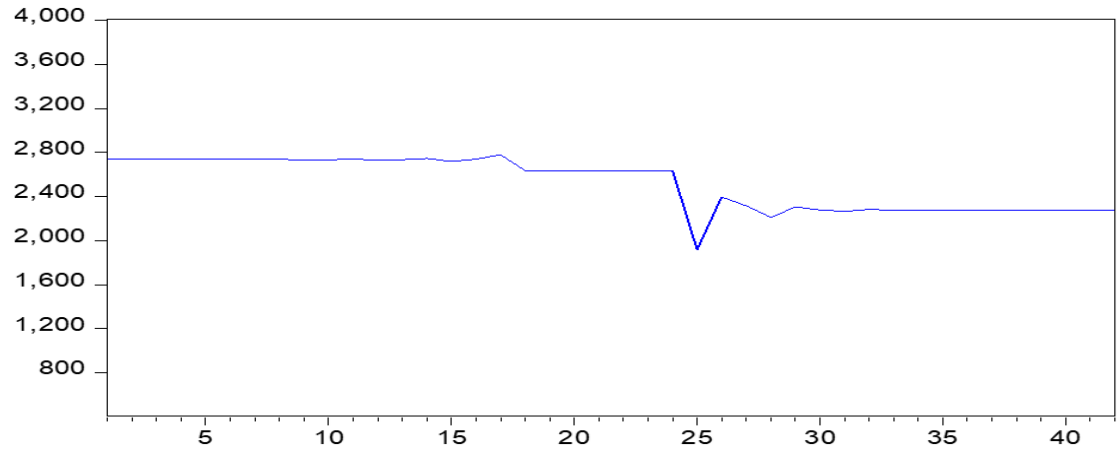

Figure 7. Evolution of paved roads between 1980 and 2021.

Unlike roads and railways, access to electricity is expanding in Kenya. In 2021, more than 67% of households had access to electricity as shown in Figure 8.

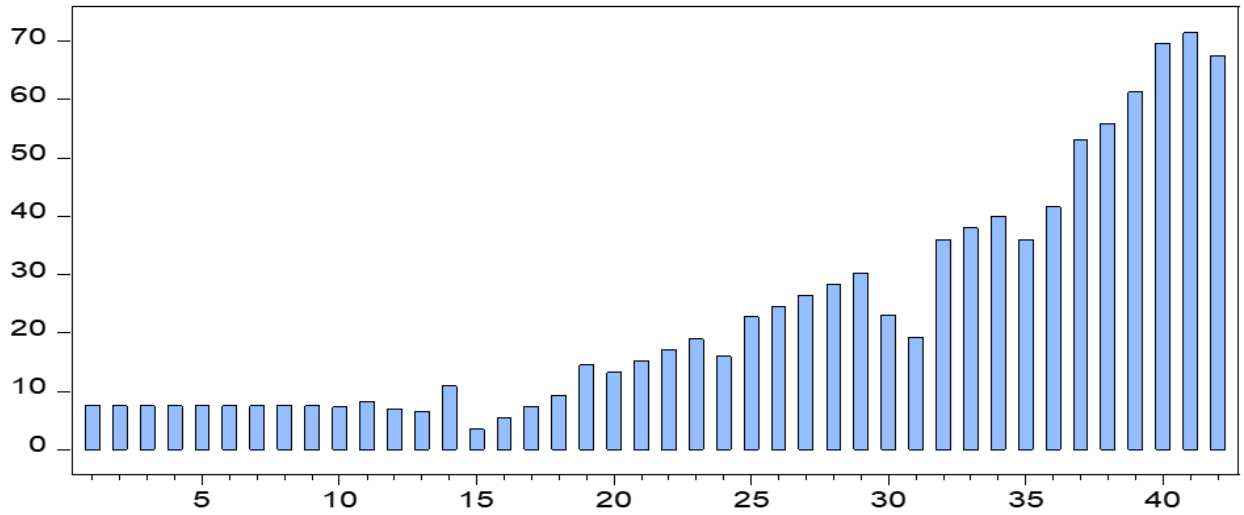

Figure 8. Evolution of electricity access between 1980 and 2021.

3. LITERATURE REVIEW

Empirically, several studies have already highlighted the economic effects of infrastructure development. This review focuses exclusively on the effect of infrastructure development on foreign trade. The work of Vemuri and Siddiqi (2009) highlighted the relationship between information and communication technologies and international trade in 64 countries during the period 1985-2005. they found a positive correlation between the two variables. On a sample of 49 countries for the period 2000-2013, Nath and Liu (2017) highlighted the fact that the development of ICT had a positive impact on international trade in 7 of the 10 service sectors. On a sample of 152 developed and developing countries, Yang (2018) demonstrated that the internet was positively correlated with international trade in services in both developed and developing countries for the period 2005-2015. Infrastructure development promotes competitiveness reducing trade costs and, therefore, by improving regional economic integration (Behar & Venables, 2011; Limao & Venables, 2001). Therefore, infrastructure development allows an economy to exploit a comparative advantage, especially in trade, and the lack of infrastructure limits international trade (Coşar & Demir, 2016; Donaubauer, Glas, Meyer, & Nunnenkamp, 2018).

Prasad, Ramamurthy, and Naidu (2001) analyzed the relationship between information and communication technologies and the export performance of 381 exporting companies in the United States. The authors found that the Internet was positively correlated with the performance of exporting companies. Information dissemination can effectively reduce communication costs and accelerate the flow of goods (Donaubauer et al., 2018). Beyond goods, the internet can also promote the cultivation of human capital by improving education (Aftab & Ismail, 2015). The work of Portugal-Perez and Wilson (2012) analyzed the effects of hard infrastructure (physical and ICT infrastructure) and intangible infrastructure on the export performance of developing countries. Using a panel of 101 countries for the period 2004-2007, they found that infrastructure improved export performance.

More infrastructure leads to industrialization and creation of many jobs, which helps reduce poverty in a country (Sahoo, Dash, & Nataraj, 2010). Karymshakov and Sulaimanova (2021) studied the impact of infrastructure on trade in Central Asia using data from three countries; Kazakhstan, Kyrgyzstan and Tajikistan. The empirical estimates are based on panel data for the period 2010-2018. The results revealed that the quality and quantity of infrastructure in Central Asia have a positive impact on trade flows. Recently, Tandrayen - Ragoobur, Ongono, and Gong (2023) found that hard and soft infrastructure improves intra-African trade and contributes to regional trade integration.

4. DATA AND ECONOMETRIC ISSUES

This section will discuss about the sample and variables that will be used in the analysis. Then, it will be followed by further reasoning about why adding each variable into the regression and the source of the data. This section also provides justifications for the estimation technique to be used.

4.1. Data

To empirically test the relationship between infrastructure development and international trade, time series data on Kenya country from 1980 to 2021 were used. The dependent variable of our econometric model is international trade. It is measured as the sum of exports and imports over the Gross Domestic Product (GDP). To test the robustness of our results, we used the openness index of Squalli and Wilson (2011) given by: $wts = \frac{(x+m)i}{\sum_{j=1}^{n}(x+m)j} \times \frac{(x+m)i}{GDPi}$, Where $x, m, GDPi$ and j respectively represent exports, imports, gross domestic product of country i and all participants in world trade. The independent variable of interest for this work is infrastructure development. It is captured in this work by rail lines, paved road and electricity. According to Faheem, Noman, and Ding (2020), infrastructure development positively influences international trade. As for the control variables, there are four: foreign direct investment, population, domestic investment and Human Immunodeficiency Virus (HIV) prevalence. The

abbreviation, measure and source for each variable is giving in appendices (see Table A1).The relation between the control variables and international trade is given in the paragraph below.

Foreign direct investment promotes infrastructure development (Zhang & Song, 2001). According to Mohsen (2015), there is a positive correlation between private investment and infrastructure development.The impact of population on international trade is positive for the exporting country, while it is negative for the importing country (Nuroglu, 2010). Regarding HIV prevalence, Gruszczynski (2020) argues that a pandemic negatively impacts international trade.

The descriptive statistics and the correlation matrix between the variables are summarized in Tables 1 and 2. Table 2 shows a positive correlation between the Infrastructure development indicators and international trade indicators.

Table 1. Descriptive statistics.

Indicators	Rail_lines	Paved road	Electricity	POP	GFCF	FDI	PHIV	TRADE	WTS
Mean	2516.460	187.428	23.169	2.909	18.795	0.705	6.5177	52.315	0.050
Median	2634.000	176.000	15.565	2.963	18.994	0.459	5.777	54.094	0.054
Maximum	2778.000	316.000	71.437	3.713	23.884	3.094	10.100	72.858	0.068
Minimum	1917.000	60.000	3.473	1.942	15.387	0.004	4.000	27.233	0.018
Std. dev.	233.630	65.299	19.767	0.522	1.923	0.738	1.762	10.655	0.014
Observations	42	42	42	42	42	42	42	42	42

Table 2. Pairwise correlation matrix.

Correlation	Rail_lines	Paved road	Electricity	POP	GFCF	FDI	PHIV	TRADE	WTS
Rail_lines	1.000								
Paved road	-0.754	1.000							
Electricity	-0.765	0.891	1.000						
POP	0.667	-0.639	-0.845	1.000					
GFCF	-0.351	0.448	0.350	-0.238	1.000				
FDI	-0.291	0.204	0.258	-0.281	0.318	1.000			
PHIV	0.441	-0.731	-0.572	0.141	-0.593	-0.142	1.000		
TRADE	0.510	0.402	0.370	0.655	-0.204	0.026	-0.554	1.000	
WTS	0.608	0.476	0.386	0.874	-0.224	-0.177	-0.295	0.746	1.000

4.2. Econometric Issues

After giving a detailed description of key variables of international trade, the relationship between them is done through econometric modelling. The aim of this work is to study the impact of infrastructure development on Kenya's international trade. Based on recent literature on the determinants of international trade (Faheem et al., 2020), we formulate the following econometric model:

$$Y_t = \alpha + \lambda\, Y_{t-1} + \sum_{p=1}^{k} \beta_p\, X_t^p + \gamma_1\, Infras_t + \varepsilon_t \quad (1)$$

Where Y_t represents the international trade at time t, X is the vector of control variables, including population, foreign direct investment, domestic investment and HIV prevalence; $Infras_t$ represents the infrastructure of the country at time t. ε_t is an error term, and α reflects the intercept. The transformation of Equation 1 into an error correction equation is given by:

$$\Delta Y_t = \varphi\,(\, Y_{t-1} - \theta_0 - \sum_{p=1}^{k} \theta_p\, X_{t-1}^p - \delta_{1i}\, Infrast_{t-1}\,) - \sum_{p=1}^{k} \beta_p\, \Delta X_t^p - \gamma_1\, \Delta Infras_t + \varepsilon_t \quad (2)$$

$$\text{Avec} \quad \theta_0 = \frac{\alpha}{1-\lambda},\ \theta_p = \frac{\beta_p}{1-\lambda},\ \delta_{1i} = \frac{\gamma_1}{1-\lambda},\ \varphi = -(1-\lambda)$$

Where $\theta_p$and δ_1 capture the dynamics of long term effects while β_p and γ_1 capture the short run dynamics and ε_t represents the error term. The adjustment speed towards the long run equilibrium is φ, it should be negative and significant to confirm the long run relationship between infrastructure development and international trade. When the variables of the econometric model are cointegrated, the Pooled Mean Group (PMG) approach is appropriate to estimate the parameters of the said model (Jouini, 2015; Pesaran et al., 1999). According to Evans (1997) and Lee, Pesaran, and Smith (1997), the Mean Group (developped by Pesaran and Smith (1995) estimates the regression for each group and provide the average coefficient. This estimation technique are inefficient if coefficent homogeneity holds while the PMG approach is useful since it provides consistent and efficient long run estimators. Moreover, the PMG is less sensitive to outlier estimates and it solve the endogeneity concerns. Equation 2 is rewritten as follows:

$$\Delta Y_t = \varphi\,(\, Y_{t-1} - \theta_0 - \sum_{p=1}^{k} \tilde{\theta}_p\, X_{t-1}^p - \tilde{\delta}_1\, Infrast_{t-1}\,) - \sum_{p=1}^{k} \beta_p\, \Delta X_t^p - \gamma_1 - \Delta Infrast_{t-1} + \varepsilon_t \quad (3)$$

5. RESULTS AND DISCUSSION

The presentation of the results of this study will be done in two stages. The first step highlights the results of the preliminary tests while the second step interprets the results from the estimation of our econometric model.

5.1. Preliminary Tests

The results of the preliminary tests of this study are articulated around three points. The first sheds light on stationary tests. As for the second, it presents the results of the cointegration test and the last point highlights the results relating to the optimal number of model lags.

Before starting the analysis of a time series, it is important to study its properties (stationary or non-stationary). Because the use of certain estimation methods is conditioned by the nature of the model variables. For this purpose, we performed Augmented Dickey-Fuller (ADF) and Phillips Peron (PP) stationary tests with intercept and trend[1]. The results of the stationary test are recorded in Table 3. This table reveals that the domestic investment and foreign direct investment variables are stationary at level while the other variables of the model are stationary in first difference.

Table 3. Stationary tests.

Variables	ADF with intercept and trend		PP with intercept and trend		Decision
	At level	First difference	At level	First difference	
Rail lines	0.7067	0.00	0.4859	0.00	I(1)
Paved roads	0.946	0.00	0.971	0.00	I(1)
Electricity	0.995	0.00	0.99	0.00	I(1)
Pop	0.775	0.00	0.942	0.00	I(1)
GFCF	0.065	-	0.071	-	I(0)
FDI	0.00	-	0.00	-	I(0)
PHIV	0.7537	0.00	0.7310	0.00	I(1)
Trade	0.5518	0.00	0.5518	0.00	I(1)
WTS	0.7540	0.00	0.7445	0.00	I(1)

Given the fact that the variables of the model are integrated at different levels, it is important to perform the cointegration test in order to verify whether there is a long run relationship between them. To this end, we carried out the Johansen's cointegration test, the results of which are recorded in Table 4. This table shows that the trace's test as well as that of the maximum eigenvalue confirms that there are respectively two and one long run relation(s) between the variables of the model.

Table 4. Johansen's cointegration test.

Unrestricted cointegration rank test (Trace)				
Hypothesized no. of CE(s)	P-value eigenvalue	Trace statistic	0.05 critical value	P-value prob.**
None *	0.752	185.167	159.529	0.000
At most 1 *	0.617	129.317	125.615	0.029
At most 2	0.589	90.839	95.753	0.103
At most 3	0.405	55.176	69.818	0.411
At most 4	0.297	34.354	47.856	0.482
At most 5	0.207	20.212	29.797	0.408
At most 6	0.163	10.9104	15.494	0.217
At most 7	0.090	3.785	3.841	0.051

Note: Trace test indicates 2 cointegrating eqn(s) at the 0.05 level.
* denotes rejection of the hypothesis at the 0.05 level.
**MacKinnon, Haug, and Michelis (1999) p-values.

Table 4. Continue…

Unrestricted cointegration rank test (Maximum eigenvalue)				
Hypothesized no. of CE(s)	P-value eigenvalue	Max-eigen statistic	0.05 critical value	P-value prob.**
None *	0.752	55.849	52.362	0.021
At most 1	0.617	38.478	46.231	0.264
At most 2	0.589	35.662	40.077	0.144
At most 3	0.405	20.822	33.876	0.697
At most 4	0.297	14.142	27.584	0.812
At most 5	0.207	9.301	21.131	0.807
At most 6	0.163	7.124	14.264	0.474
At most 7	0.090	3.785	3.841	0.051

Note: Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level.
* denotes rejection of the hypothesis at the 0.05 level.
**MacKinnon et al. (1999) p-values.

[1] For the intercept, we have to look whether the data is around 0 (on the y-axis) or not. If is not around 0, you need to include an intercept. For the trend, we have to check whether your data is going into a clear direction, more or less close to a straight line.

In the presence of cointegration, several methods of estimating the parameters are recommended like FMOLS (Fully Modified Ordinary), DOLS (Dynamic Ordinary Least Squares) and ARDL. The methods for estimating cointegrating relationships such as FMOLS or (DOLS) require that all the variables are integrated at order one. To overcome this condition, Pesaran and Shin (1999) demonstrated that cointegrating systems can be estimated as autoregressive and distributed Lags (ARDL) models. Considering that the ARDL is applied on a dynamic model, it is important to find the optimal number of model lags. Table 5 gives the results of the optimal number of model lags. This table shows that this number is equal to one for all the information criteria (LR, FPE, AIC, SC, HQ).

Table 5. Choice of information criteria (Optimal number of model lags).

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-299.419	NA	17706.23	15.457	15.542	15.488
1	-230.729	126.811*	642.161*	12.139*	12.395*	12.231*
2	-229.391	2.333	737.708	12.276	12.703	12.429
3	-226.731	4.364	794.177	12.345	12.942	12.559

Note: The line that has more stars(*) thant the others indicates the optimal lags of our model. The optimal lags here is 1.

5.2. Results of the Econometric Model Estimation

The results of our econometric model are recorded in the next three tables. Table 6 highlights the effect of infrastructure development on the openness rate through the ARDL method. As for Table 7, it repeats the estimates of Table 6 using an alternative measure of international trade (Squalli and Wilson index). Finally, Table 8 presents the robustness of the results across the FMOLS and DOLS methods.

The estimation of the international trade equation by the ARDL method shows that the speed of adjustment (also called the error correction term) is negative and significant for the three columns, confirming the cointegration relationship between the variables and implying that the link between international trade and explanatory variables is characterized by high predictability and that the spread movement is mean-reverting (Table 6). For example, the value of the error correction term is -0.6297 for column 3. This value corresponds to 6.29 years, which means that the time it takes for international trade to deviate from it equilibrium level is reabsorbed between 6 and 7 years. It suggests that the return to equilibrium is not immediate. The results in column 3 reveal that except FDI, all the explanatory variables significantly influence the long run dynamics of international trade. However, only population and domestic investment variables are significant both in the short and long run.

The analysis of Table 6 shows that through the ARDL method (robust to autocorrelation and heteroskedasticity issues), the development of infrastructures has no effect on the rate of openness in the short run. However, it contributes positively and significantly to the openness rate of Kenya in the long run. Specifically, an increase in rail lines, paved roads and access to electricity by one unit leads to an improvement in the opening rate of 30%, 16% and 4% respectively. This result can be explained by the fact that infrastructure plays a vital role in promoting trade. For example, transport infrastructure such as railways and paved roads can help a country connect its remote areas domestically on the one hand and on the other hand to commercial areas around the world at low cost (Donaubauer et al., 2018). Moreover, quality roads make it possible to open up the production basins in order to facilitate the transport at a lower cost of the raw materials necessary for industrial production, this helps to boost exports. In the same dynamic, good quality energy infrastructure promotes capital intensive industrialization and thus reduces production costs; which allows industrial companies to be competitive and face up to foreign competition.

With regard to population growth, it has a positive and significant effect on international trade in the short and long run. Thus, a population increase of 1% leads to an improvement in international trade of 1% (column 3). This result can be explained by the fact that when the population increases, it constitutes a labour force for national production and therefore for export sectors. On the other hand, an increase in population also translates into an increase in external demand, which induces an increase in imports. This result is consistent with the work of Nuroglu (2010), who found that population enhances international trade for the exporting country and hinders trade for the importing country.

Domestic investment has a positive and significant effect on international trade in both the short and long run. Thus, an increase in domestic investment of 1% promotes the development of international trade of 0.5% and 0.79% respectively in the short and long run (column 3). This result can be explained by the fact that an increase in domestic investment favours the acceleration of the industrialization process which are categorized as factors that stimulate international trade. This result is compatible with the work of Mohsen (2015).

Regarding HIV prevalence, it has no effect on international trade in the short term. However, it has a negative and significant effect on long run trade flow. Thus, an increase in the level of HIV prevalence of 1% leads to a drop in trade of 0.06% (column 3). This result is explained by the fact that the increase in the HIV prevalence rate impacts the psychology of infected people and therefore reduces their productivity. The decline in the productivity of patients leads to a decline in national production and that of the exporting sector. Anything that promotes a decline in international trade. This result is compatible with the work of Gruszczynski (2020) who argued that a pandemic negatively impacts international trade.

Table 6. Effect of infrastructure development on the openness rate.

Long run	1	2	3
Log (Rail lines)	0.3007*** (0.00)		
Log (Paved roads)		0.1602** (0.02)	
Log(Electricity)			0.0438*** 0.00)
Log (Pop)	0.6532*** 0.00)	0.7621*** 0.00)	1.00 3*** (0.00)
Log(GFCF)	0.4954** (0.01)	0.7020** (0.02)	0.7943*** (0.00)
Log(FDI)	0.0209 (0.1)	0.0394* (0.08)	0.0326 (0.1)
Log(PHIV)	-0.0443*** (0.00)	-0.0450*** (0.00)	-0.0663** (0.00)
Cons.	2.0663** (0.03)	0.6472*** (0.00)	0.4870*** (0.00)
ECM	-0.9463*** (0.00)	-0.05908*** (0.00)	-0.6297*** (0.00)
Short run dynamic			
DLog (Rail lines)	0.4481 (0.1)		
DLog(Paved roads)		0.0946 (0.1)	
DLog(Electricity)			0.0275 (0.4)
DLog(pop)	0.9735*** (0.00)	0.4502*** (0.00)	0.6299*** (0.00)
DLog(GFCF)	0.7383*** (0.00)	0.4147** (0.04)	0.500** (0.01)
DLog(FDI)	0.0312 (0.1)	0.0232* (0.08)	0.0205 (0.1)
DLog(PHIV)	-0.6472 (0.3)	-0.2662 (0.5)	-0.4017 (0.8)
Adjust R^2	0.84	0.87	0.86
Breusch-Godfrey	0.84	0.48	0.58
Breusch -Pagan-Godfrey	0.72	0.90	0.73
Remsey reset	0.49	0.83	0.65
Wald test [Prob(Chi2)]	0.00	0.00	0.00

Note: *** p<0.01, ** p<0.05, * p<0.1. The value in parentheses represent the probabilities.

To test the robustness of this results, we used another proxy for international trade: the Squalli and Wilson index. The results of this analysis are recorded in Table 7. It is apparent from this table that infrastructure development improves Kenya's international trade. Overall, the three infrastructure indicators used in this work are all positive and significant. Which is proof that our results are robust. Moreover, the analysis of the effect of infrastructure development on international trade using the FMOLS and DOLS methods confirms this robustness. The results of this analysis are recorded in Table 8.

Table 7. Effect of infrastructure development on the openness index of Squalli and Wilson.

Long run	1	2	3
Log (Rail lines)	0.271*** (0.00)		
Log (Paved roads)		0.127** (0.02)	
Log(Electricity)			0.034*** 0.00)
Log (Pop)	0.786*** 0.00)	0.696*** 0.00)	0.695*** (0.00)
Log(GFCF)	0.008 (0.9)	0.010 (0.9)	0.006 (0.00)
Log(FDI)	0.004 (0.8)	0.001 (0.9)	0.002 (0.9)

Long run	1	2	3
Log(PHIV)	-0.143 (0.2)	-0.088 (0.5)	-0.107 (0.4)
Cons.	0.268*** (0.00)	2.045*** (0.00)	2.217*** (0.00)
ECM	-0.430*** (0.00)	-0.431*** (0.00)	-0.431*** (0.00)
Short run dynamic			
DLog (Rail lines)	0.631(0.3)		
DLog(Paved roads)		0.0379(0.7)	
DLog(Electricity)			0.015***(0.00)
DLog(Pop)	1.826***(0.00)	1.613***(0.00)	1.613***(0.00)
DLog(GFCF)	0.018(0.9)	0.024(0.9)	0.015(0.9)
DLog(FDI)	0.009(0.8)	0.004(0.9)	0.004(0.9)
DLog(PHIV)	-0.332(0.2)	-0.206(0.7)	-0.250(0.4)
Adjust R^2	0.87	0.87	0.84
Breusch-Godfrey	0.28	0.39	0.26
Breusch -Pagan-Godfrey	0.17	0.19	0.14
Remsey reset	0.36	0.91	0.42
Wald test [Prob(Chi2)]	0.00	0.00	0.00

Note: *** p<0.01, ** p<0.05. The value in parentheses represent the probabilities.

Table 8. Effect of infrastructure development on international trade through the FMOLS and DOLS methods.

Long run	FMOLS			DOLS		
	1	2	3	1	2	3
Log (Rail lines)	0.2118*** (0.00)			0.1835*** (0.00)		
Log (Paved roads)		0.0554*** (0.00)			0.0931*** (0.00)	
Log(Electricity)			0.0203* (0.05)			0.0562** (0.04)
Log (Pop)	0.9335*** (0.00)	0.7918*** (0.00)	0.8962*** (0.00)	0.9443** (0.00)	0.8218*** (0.00)	0.9838*** (0.00)
Log(GFCF)	0.6964*** (0.00)	0.6896*** (0.00)	0.7263*** (0.00)	0.6650*** (0.00)	0.7282*** (0.00)	0.7558*** (0.00)
Log(FDI)	0.0308* (0.06)	0.0338* (0.07)	0.0318* (0.08)	0.0336** (0.02)	0.0368** (0.04)	0.0340** (0.04)
Log(PHIV)	-0.5192** (0.00)	-0.6000*** (0.00)	-0.6107*** (0.00)	-0.6107*** (0.00)	-0.5747*** (0.00)	-0.6666*** (0.00)
Cons	0.4423* (0.07)	0.1180** (0.02)	0.3957** (0.03)	0.3957** (0.03)	0.0669* (0.06)	0.6730*** (0.00)
Adjust R^2	0.82	0.83	0.81	0.82	0.80	0.83

Note: *** p<0.01, ** p<0.05, * p<0.1. The value in parentheses represent the probabilities.

6. CONCLUSION AND POLICY RECOMMENDATIONS

The last two decades have been marked by an unprecedented decline in Kenya's foreign trade. The objective of this work is to examine the factors likely to boost the foreign trade of this country. By mobilizing the ARDL method on data covering the period 1980-2021, the results revealed that infrastructure development lead to an improvement in Kenya's foreign trade in the long run. Based on the above results, some policy recommendations have been formulated. The Kenya State must continue to build its infrastructures. More concretely, it must continue to implement the projects recorded in the 2014-2023 Country Strategy Document with the agreement of the African Development Bank Group. Furthermore, it must pursue its national infrastructure development program with the support of other development partners by emphasizing the intensification of electricity, the construction of roads and railway lines. To achieve its infrastructure goals Kenya needs to develop the second phase of the Country Strategy Document. This is a ten-year plan covering the period 2024-2033. It is urgent to implement the "Territorial planning and development of transport infrastructure" axis which aims for the following results: (1) National strategies for the development of harmonized land road infrastructure; (2) Improved transnational transport infrastructure (road, rail and river); (3) Harmonized policies and regulatory frameworks for transport (road, rail and river); (4) Improved airway connectivity with its neighbours; (5) Improved shipping lane connectivity. In view of the infrastructure deficit, the priority of this document will be to put greater emphasis not only on the development of transport infrastructure, but also on the energy infrastructure necessary for production.

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Institutional Review Board Statement: The Ethical Committee of the University of Omar Bongo, Gabon has granted approval for this study (Ref. No. 21).
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Competing Interests: The authors declare that they have no competing interests.
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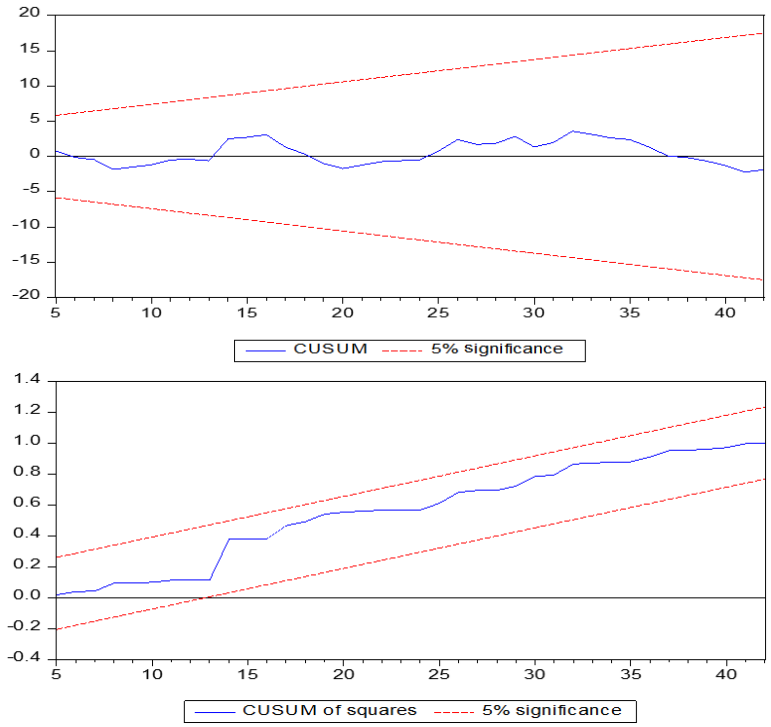
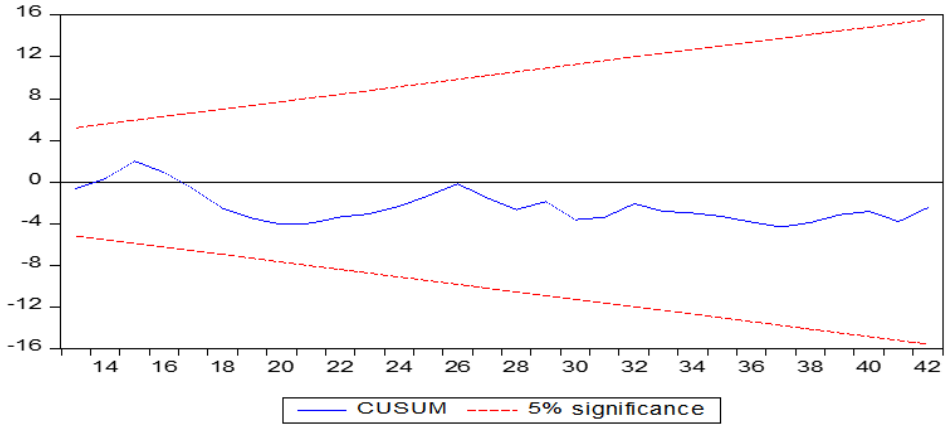
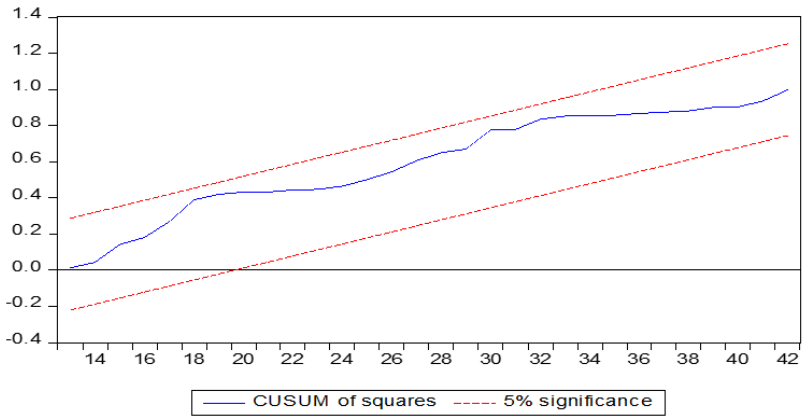
Appendix

CUSUM's test presents the stability model related to rail lines and trade.

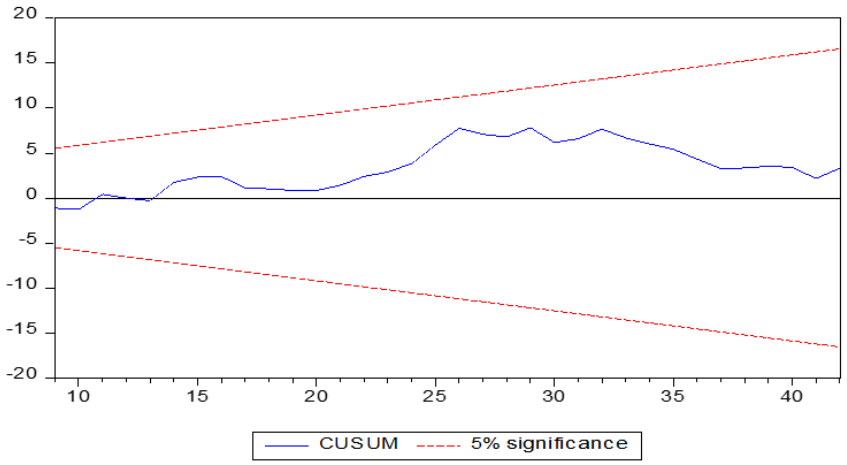


CUSUM's test establishes the stability modelpaved roads and trade.





CUSUM's test presents the stability model related to electricity and trade.



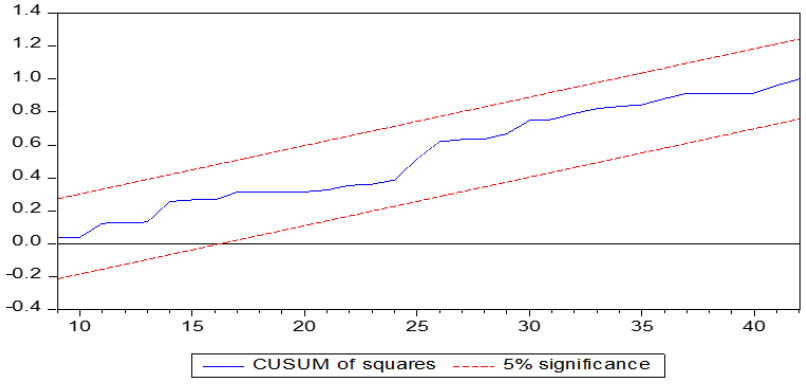


Table A1. Summary of the different variables present in this study.

Variables	Signs	Variables definition (Measurement)	Sources
Population growth	POP	Annual population growth rate. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.	World bank
Rail lines (Total route-km)	Rail lines	Rail lines are the length of railway route available for train service, irrespective of the number of parallel tracks.	World bank
Prevalence of HIV, total (% of population ages 15-49)	PHIV	Prevalence of HIV refers to the percentage of people ages 15-49 who are infected with HIV.	World bank
Access to electricity (% of population)	Electricity	Access to electricity is the percentage of population with access to electricity. Electrification data are collected from industry, national surveys and international sources.	World bank
Paved roads	Paved roads	Paved roads as a % of total roads	World bank
Private investment	INV	Gross fixed capital formation (% GDP)	World bank
Foreign direct investment	FDI	Foreign direct investments, net inflow (% of GDP)	World bank
International trade	Trade	Squalli and Wilson index / Total imports and exports to GDP.	Authors/ World bank