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Modeling Long-Run Relationships between Transport, FDI, Human Capital, and Economic Development in 25 African Countries

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Abstract

This study aims to investigate the long-term relationships between foreign direct investment (FDI), human capital accumulation, freight transportation, and economic growth in 25 African countries across three distinct regions—Southern Africa, Central Africa, and North Africa—over a span of 25 years (1995-2020). Employing fully modified ordinary least squares and dynamic ordinary least squares estimators, the empirical analysis reveals bi-directional and predominantly positive long-run relationships between the variables. However, certain linkages demonstrate unidirectional trends, particularly the relationship between FDI and human capital in Southern and Central African regions, albeit with minor statistical significance. Notably, negligible associations were found between freight transportation and human capital across all cases. The findings underscore the significant impact of an efficient transportation system on facilitating FDI inflows, substantially contributing to the development of human capital—a pivotal driver of long-term economic growth in recipient countries. Finally, robustness checks to validate the results through the GMM estimators are performed. The implications suggest the crucial role of enhancing transportation infrastructure in fostering FDI and subsequently nurturing human capital, thereby fueling sustained economic growth in these African nations.

Keywords: Human Capital; Economic Growth; Freight Transportation; Foreign Direct Investment Inflows; FMOLS; DOLS.

JEL: O18; F21; H54; J24

1. Introduction

Increasing commercial exchanges between regions and countries affects strongly the economic growth of both developed and developing countries. Also, the globalization and international economic openness increase the volume of foreign direct investments in the world. Several economists and researchers prove the main positive impact of FDI inflows on the economic growth in the host countries (Khan et al., 2020; Janesh and Kreishan, 2012; Sanfilippo,

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2010; Blomström et al., 1994). These authors indicate that developing countries, like African countries, should adopt new strategies to improve their attractiveness for international companies. They also note that international competition between beneficiary countries is becoming more intense and that multinationals are increasingly strict in selecting a new location for their new affiliates.

The African attractiveness of FDI which is based on the known economic factors is no longer enough. For many years, to increase their attractiveness, African countries have offered their natural resources to international investors and provided favorable regulations and cheap labor force. Sanfilippo (2010) found that the entry of Chinese FDI in 41 African countries was based mainly on natural resources endowments and market potential. However, many factors can increase the attractiveness of FDI and allow host countries and multinationals to obtain additional advantages simultaneously. Saidi (2016) argues that transport and logistics as well as human capital accumulation can be considered as main elements having a significant and positive effect on FDI inflows. Indeed, during an operation to set up abroad, particularly in Africa, several problems can complicate the process and prolong delays, such as administrative procedures and customs operations.

Several economists prove that a modern and developed transport system as well as effective logistics can enormously solve these problems and ensure the fluidity of the various operations (Saidi, 2016; Abdul Rahman et al., 2011; Erenberg, 1993, Zhou, et al., 2002; Wei, 2000). These authors confirm largely the main contribution of transport and logistics to ameliorate the FDI attractiveness in developing countries. They conclude that the African countries, like the other developing countries, need to pay close attention to their basic infrastructures. To realize an economic growth, these countries need to build new infrastructures and maintain the existing ones. Furthermore, the needs of multinationals to export and import different flows (human, capital, technological, informational, etc.) justify their demand for developed transport and logistics.

The neoclassical economic approach assumes that the significant impact of FDI inflows on the economic development of recipient countries is limited to creating jobs, promoting exports and maintaining economic openness. These positive impacts are positive and only significantly affect economic development in the short term. However, with the endogenous economic approach, FDI inflows have various long-term positive impacts and stimulate the economic growth of developing countries for long periods. Regarding the hypothesis of this new economic theory, the accumulation of stocks of human, technological and public capital is the major engine of long-term economic growth (Romer, 1986, 1990; Lucas, 1998; Barro, 1990). Host countries must adopt effective long-term planning to increase the sustainable impacts of FDI on the accumulation of capital stocks. Borensztein et al. (1998) confirm the ability of FDI to accelerate the improvement of capital stocks. They also show that FDI contributes to the economic growth of the beneficiary regions if they contribute to increasing the stock of knowledge. Similarly, significant effects can be observed on human and public stocks suitable for economic development. The OECD (2003) reports that foreign investment serves to create dynamic advantages useful for accelerating the transmission of technology, improving the

skills of human capital and intensifying public capital.

The primary objective of this article is to delve into critical research issues: 1) The pivotal role of transportation systems in bolstering territorial attractiveness, particularly in developing African countries. 2) Multinational companies' entry significantly enhances the accumulation of human capital in African countries. 3) Skilled human resources play a key role in facilitating the rapid transfer of technologies within the domestic economy.

This study enriches the existing literature in several ways: (i) It examines the interlinked relationships among FDI, human capital, transportation, and economic growth simultaneously. (ii) The research spans 25 African countries across a 25-year period from 1995 to 2020. (iii) The countries are categorized into three sub-panels: North African countries (NAC), Central African countries (CAC), and South African countries (SAC). (iv) The empirical investigation employs the Fully Modified Ordinary Least Squares (FLOLS) and Dynamic Ordinary Least Squares (DOLS) methodologies.

The study's key conclusions offer significant guidance to policymakers in African countries and developing nations, emphasizing the critical importance of fundamental infrastructures, particularly in transportation. Both national and international transportation networks play a substantial role in fostering economic development. Moreover, there is a substantial impact on the human resources in host countries due to the positive bidirectional causality between transport and FDI inflows. Ultimately, sustained long-term economic growth necessitates robust human, technological, and public capital stocks.

The present work contains five sections presented as follows: section 1 gives a theoretical and empirical literature review. Section 2 presents the model, data and econometric methodology. Section 3 encloses the principal results and interpretations. Section 4 provides the robustness check. Section five concludes the article with the policy implications.

2. Literature review

2.1. Theoretical literature review

Wheeler and Mody, (1992); Asiedu, (2002) and Loree and Guisinger, (1995) are among the first authors who discussed the key role of transport infrastructures in improving the economic development through the canal of the FDI inflows. Saidi (2016) studied the impact of transport systems on the FDI inflows in the MENA countries between 2000 and 2014. The author proves that the FDI attractiveness is essentially based on a specific group of economic factors. However, he notes that the transport infrastructures have an increasing importance as a new factor of the FDI for the host countries. Zhu et al., (2020); Sharif et al., (2019) argue that the public infrastructures, particularly those of transport, support largely the economic development of nations. Thus, they concluded that railways are greatly involved in the growth of both developed and developing countries. Furthermore, the capacity and efficiency of transport systems greatly affects the competence of multinationals as well as national companies. Indeed, with an increasing competition, firms try to differentiate themselves by their particular offerings. They decide to implement in ports and in well-equipped logistics areas offering the best possible conditions of transport.

In addition, over the past few decades, efficient and modern transport systems have significantly influenced the final decision of

multinationals to internationalize. They strongly motivate the decision-makers of international companies to expand their activities and enter new markets. In fact, developed transport systems offer new opportunities for people and businesses to benefit more from globalization and international trade openness. Brainard (1997) maintains that by employing modern transport infrastructures, American firms can easily develop and expand their investments abroad. The author, among others, argues that the qualities of transport systems in terms of speed, cost, and safety allow companies to increase their competitiveness. In the same vein, we found that various research studies prove the major role of transport to attract the foreign investors (Coughlin et al., 1991; Loree and Guisinger,, 1995). They say that the multinationals consider the transport as a vital component of their success as well as human and financial capitals. For these reasons, recipient countries strive to develop their local and international transport networks to attract foreign investors. They recognize the benefits of FDI inflows for their development through the positive effects on many economic sectors. Following the same line of thought, Magazzino and Mele (2021) corroborate the favorable influence of transportation infrastructure on economic progress in China between 1990 and 2017. Their conclusion underscores the critical significance of infrastructure maintenance to sustain this positive impact over extended periods.

In the same order of ideas, several economists and researchers investigate the long-run impact of FDI inflows on the economic development of the host countries. Markusen, (1995); Kinoshita, (1998) and others have focused their interests on the specific role of FDI on the accumulation of human capital stock. They note that by creating new subsidiaries abroad, multinational firms participate in the technological change of the beneficiary territory. They accelerate the transfer of technologies and practices to national companies. Lucas (1988) stated that foreign investment is attracted to regions and countries where it can benefit from a greater number of qualified and skilled employees. On the other hand, Mishra et al (2001) have shown that the existence of foreign companies in a given region contributes greatly to improving its power of attractiveness by convincing other companies to come and invest there. Blomström and Kokko (1998) examine the contribution of multinationals to workforce training in developing countries. These companies push the local communities to increase their investments in human capital by giving more importance to education at its various levels. Regarding the relationship between FDI inflows and economic growth in Malta between 1971 and 2017, Magazzino and Mele (2022) support the neutrality hypothesis, as the relationship is non-significant over extended periods. Additionally, the authors assess the robustness by utilizing Artificial Neural Networks (ANNs) to predict changes in FDI inflows concerning economic growth in Malta.

In addition, Blomström and Persson (1983) prove that a high quality of Mexican human capital promotes FDI entry with advanced technologies, which are useful for increasing the qualification of the local workforce. However, with low-skilled human capital, host countries become attractive for foreign investment with poor technologies. Consequently, the impact on the accumulation of human capital stock, therefore the economic growth, is still minimal and marginally affects the enhancement of local workers qualifications. Based on these

results, Blomström and Persson (1983) conclude that the human capital stock impact significantly the economic development in both developing and developed countries.

Inspired by the important findings of Blomström and Persson (1983), several economists attempt to confirm the significant contribution of a skilled human capital to economic growth (Romer, 1990; De Gregorio and Lee, 2003). Andreosso-O'Callaghan (2002) used data from 10 Asian countries over three years (1980, 1990 and 1997) to value the impact of employees' educational levels on their productivity. The author concluded that educated human capital plays an essential role in the development of productivity, which positively affects the growth of these countries. Using the same technique, Aghion and Cohen (2004) study the same nexus for 110 countries over 40 years. They represent human capital by the number of years of study for employees. The main conclusions note that the productivity always increases with the education, which positively affects economic development. Lucas (1988) studied these relationships differently. He indicates that the efficiency of individuals can develop more rapidly in societies where the general level of human capital is higher, such as in developed countries. Accordingly, the knowledge accumulated in societies helps people to improve their skills more easily and for free of charge. Indeed, the existence of effective management, guidance and education personnel ensures an effective education system (Pigalle, 1994; Rajhi, 1996).

2.2. Empirical literature Review

In the following section, we aim to present the main findings of several empirical studies investigating the relationships among freight transportation, foreign direct investment inflows, human capital accumulation and economic development that employed various modeling techniques. In the same vein, we want to review the studies on panel data models as they come closer to our study and therefore provide at least some insight into the link between the main variables of our present study (FT, HK, FDI, and Y).

Starting with unidirectional links, Johanson (2005) used data from 90 countries with different income levels to examine the relationships between growth and FDI inflow over 22 years (1980-2002). The main conclusion shows that the economic growth of developing countries is largely affected by the entry of foreign firms. However, FDI inflows depend positively but marginally on economic growth. Also, Udemba et al. (2020) expose the interplay between pollutant emissions, FDI, energy demand, tourism arrival and economic development in China using quarterly frequency data from 1995Q1 to 2016Q4. Using Pesaran's distributed autoregressive test, they found a positive and significant impact of FDI on Chinese economic growth but without feedback effect. Teixeira and Queirós (2016) examine the long-run causalities between human resources and growth for developed countries (21 OCDE countries) over the period 1960-2011. Growth model integrated variables from both the supply and demand side was applied. The principal findings note that the labors and the countries' productive patterns represent an important component of the economic development for the OCDE countries. To estimate the causal relationship between human capital accumulation and key macroeconomic variables in Pakistan, Qadri and Waheed (2014) adopt the Monte Carlo approach over 5 years (2012-2016). In an empirical analysis, they follow Keynesian and neoclassical theory to model demand

and supply respectively. The authors found that the long-term relationship is positive and statistically insignificant.

In addition, the fixed effects models are used by Majeed and Ahmed (2008) to inspect the effect of human resources on FDI entry in developing countries. The authors exploited the data of 23 countries over the period between 1970 and 2004. Indeed, the human capital development was measured by health expenditures and illiteracy rate. The authors conclude that the human capital affects significantly the FDI entry on developing countries. Heyuan and Teixeira (2010) examine the relationship between FDI inflows and the stock of human capital in China. To measure human capital, the authors consider academic qualifications. For a sample of 78 companies, the results show that FDI inflows depend slightly on the qualities and skills of Chinese human resources. Additionally, another study was performed by Cleeve et al. (2015) to measure the influence of human capital on FDI attraction in 35 African countries. Using numerous measures of human capital stock, the authors determine that FDI inflows largely affect all measures of HK in sub-Saharan countries over the period from 1980 to 2012.

On the other hand, there are many empirical studies in which economists prove bidirectional relationships between FDI inflows, economic growth and transport infrastructure. Using the generalized method of moments, Saidi et al. (2020) found positive and bidirectional relationships between growth, FDI and transport for 46 countries between 2000 and 2016. Similarly, Khadaroo and Seetanah (2008) prove the positive and bi-directional causalities between transportation and growth in Mauritius over 1950-2000. Their results show also that modern transport infrastructure stimulates economic development by increasing accessibility and reducing transport costs. In addition, they say that economic development positively influences the development of transport networks in Mauritius.

Magazzino and Cerulli (2019) discuss differently the long-run relationship between economic growth and foreign trade by introducing the carbon dioxide emissions and energy consumption as additional variables of control. Using a Responsiveness Scores (RS) approach, the authors examine these causalities for the MENA region over the period 1971-2013. In the final conclusion, they confirm that the relationship between economic growth and foreign trade is bidirectional and positive in the two directions. Also, Magazzino and Valeri (2012) conduct another study to verify the linkages among capital stock, total labor force and total factor productivity in Italian transportation system for 37 years (1970-2007). The relationship between real public capital and labor force as well as between public capital and total factor productivity is bi-directional. Another study regarding Italy was carried out by Magazzino and Giolli (2021), spanning the period 1861 - 1970. The authors utilized both the AutoRegressive Distributed Lags (ARDL) model and Wavelet Analysis (WA) to examine the correlation between railway networks and real GDP while considering energy consumption. Their primary findings confirm a positive relationship between these variables, underscoring that railway networks play a pivotal role in driving economic growth in the Italian context.

Völlmecke et al. (2016) treat income convergence in regional GDP per capita for 269 regions within the European Union between 2003 and 2010. In their empirical investigation the authors apply a Markov chain

approach that exploits micro-aggregated sub-national FDI statistics. Their main findings approve the feedback hypothesis between foreign direct investment and human capital stock for all European regions. Similarly, Kheng et al. (2017) inspect the interrelationship among human resources and foreign investment inflows for 55 developing countries for the period between 1980 and 2011. The use of the simultaneous equations model proves the existence of positive and significant bidirectional causalities between the two variables.

In Table-1 below, we summarize the literature mentioned above. From this table, we can clearly see that the four-way relationship between freight transport, foreign direct investment, human capital and economic growth in Africa is not examined by any of these studies. For this reason, we have found great motivation to fill this gap by applying panel cointegration approaches, Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS) in the case of 25 African countries over the period 1995-2020.

Table-1. Summary of existing empirical studies

Author(s)	Countries	Period	Causality results
Li and Liu (2005)	84 countries	1970–1999	HK $\longrightarrow$ FDI
Johanson (2005)	90 countries	1980–2002	FDI $\longrightarrow$ Y
Su and Nguyen (2022)	38 African countries	2002–2017	FDI $\leftrightarrow$ Y HK $\leftrightarrow$ Y FDI $\leftrightarrow$ HK
Majeed and Ahmad (2008)	23 developing countries	1970–2004	HK $\longrightarrow$ FDI
Heyuan and Teixeira (2010)	78 firms	2008	HK $\neq$ FDI
Onye et al. (2022)	ECOWAS countries	2005–2018	T $\longrightarrow$ Y
Teixeira and Queirós (2016)	21 OCDE countries	1960–2011	HK $\longrightarrow$ Y
Bouchoucha and Ali (2019)	Tunisia	1980–2015	FDI $\longrightarrow$ Y
Udemba et al. (2020)	China	1995Q1- 2016Q4	FDI $\longrightarrow$ Y
Khadaroo and Seetanah (2008)	Mauritius	1980-2000	T $\leftrightarrow$ Y
Hana and Lee (2020)	Korea	1986–2017	HK $\longrightarrow$ Y
Al-Iriani (2006)	6 Gulf countries	1971–2001	FDI $\leftrightarrow$ Y
Rudra and Pradhan (2009)	5 ASEAN countries	1970–2007	FDI $\leftrightarrow$ Y
Brida et al. (2016)	Mexico	1995-2013	T $\leftrightarrow$ Y
Magazzino and Cerulli (2019)	Mena countries	1971-2013	Y $\leftrightarrow$ FDT
Inekwe (2013)	Nigeria	1990-2009	FDI $\leftrightarrow$ Y
Moudatsou and Kyrkilis (2011)	26 countries	1970–2003.	FDI $\leftrightarrow$ Y
Jin and Rafferty, (2017)	United States	1990-2000	T $\longrightarrow$ Y
Omri and Kahouli (2014)	13 MENA countries	1990–2010.	FDI $\leftrightarrow$ Y
Lau et al. (2014)	Malaysia	1970–2008	FDI $\leftrightarrow$ Y
Völlmecke et al. (2016)	European regions	2003–2010	FDI $\leftrightarrow$ HK

Author(s)	Countries	Period	Causality results
Kheng et al. (2017)	55 Developing countries	1980–2011	FDI ↔ HK
Saidi et al. (2020)	46 countries	2000-2016	FDI ↔ Y Y ↔ T T ↔ FDI
Saidi (2016)	12 MENA countries	2000-2014	T ↔ FDI
Saidi and Mefteh (2020)	63 countries	2000-2016	T ↔ FDI
Ranis et al. (2000)	76 developing countries	1960–1992	HK ↔ Y
Marazzo et al. (2010)	Brazil	1966-2006	Y ↔ T
Maparu and Mazumder (2017)	India	1990-2011	T ↔ Y
Fedderke et al. (2006)	South Africa	1875-2001	Y → Y
Cleeve et al. (2015)	35 African countries	1980-2012	FDI → HK
Pradhan and Bagchi (2013)	Côte d'ivoire	1980-2013	FDI ↔ Y T ↔ FDI T ↔ Y
Keho and Echui (2011)	Côte d'ivoire	1970-2002	Y → T
Dutta and Osei-Yeboah (2010)	76 developing countries	1980–2003	HK ↔ FDI

→ and ↔ indicate unidirectional causality and bidirectional hypothesis respectively
Y, FDI, T, HK refer to economic growth, foreign direct investment inflows, transport and human capital respectively.

3. Methodology and Econometric Method

3.1. Empirical Models

Several researchers have explored the long-term relationship between transportation, foreign direct investment, human capital accumulation and economic growth (Pradhan and Bagchi, 2013; Demurger, 2001; Kheng et al., 2017; Hana and Lee, 2020; Halaszovich and Kinra, 2018). In general, economists have identified a positive correlation among these variables, which has a beneficial impact on long-term economic growth.

When focusing on African countries, Cleeve et al. (2015) demonstrated that the development of public infrastructure improves the attractiveness of foreign direct investment in 14 African nations. Inkwe (2013) investigated the causal relationships between foreign direct investment, employment, and economic growth in Nigeria (1990-2009). The primary findings indicate that FDI in the servicing sector has a positive relationship with economic growth, while FDI in the manufacturing sector has a negative relationship. However, FDI in the manufacturing sector exhibits a positive relationship with the employment rate, whereas FDI in the servicing sector shows a negative relationship with the employment rate.

Inspired by the findings of these works and others, we found great motivation to treat the long-run causalities between freight transportation, foreign direct investment inflows, human capital accumulation and

economic growth for 25 African countries between 1995 and 2020 using the following specification:

$$Y = f(FT, FDI, HK, Z) \quad (1)$$

Where Y is the economic growth, FT is the transportation of freight, FDI is the foreign direct investment inflows, HK is the human capital stock in the recipient economies, and Z is a vector of control variables. Following the conventional Cobb-Douglas production function, Equation (1) can be rewritten as follows:

$$Y_{i,t} = FT_{i,t}^{\alpha} FDI_{i,t}^{\beta} HK_{i,t}^{\lambda} Ze^{i,t} \quad (2)$$

Where α, β and λ represent the effects of the FT, FDI and HK respectively. In this survey, we assumed the freight transport, foreign direct investment and human capital remain among the major drivers of economic growth in the developing countries (Madden and Savage, 2000; Demurger, 2001; Datta and Agarwal, 2004; Ding et al., 2008; Nasreen and Anwar, 2014; Shahbaz et al., 2017; Magazzino, 2017). In fact, we will predict that the parameters α, β and λ have positive signs. Taking the natural logarithm in Eq. (2), the empirical model proposed in the panel is the following:

$$\ln Y_{i,t} = \alpha_0 + \alpha_1 \ln FT_{i,t} + \alpha_2 \ln FDI_{i,t} + \alpha_3 \ln HK_{i,t} + \alpha_4 \ln Z_{i,t} + \varepsilon_{i,t} \quad (3)$$

Where i is the country (in our study, we have 25 countries); t represents time (our time frame is 1995–2020). Furthermore, in Eq. (3), ε is called the error term, and Z is a vector of control variables (including K as domestic capital, I as inflation rate, E as energy consumption, TO as trade openness, and POP as the population density). The four-way relationships between Y–FDI–FT–HK are simultaneously analyzed into the following four equations:

$$ln\, Y_{i,t} = \alpha_0\, ln\, Y_{i,t-1} + \alpha_{1,i}\, ln\, F\, DI_{i,t} + \alpha_{2,t}\, ln\, F\, T_{i,t} + \alpha_{3,i}\, ln\, H\, K_{i,t} + \alpha_{4,i}\, ln\, K_{i,t} + \alpha_{5,i}\, ln\, I_{i,t}\, \varepsilon_{i,t} \quad (4)$$

$$ln\, F\, DI_{i,t} = \beta_0\, ln\, F\, DI_{i,t-1} + \beta_{1,i}\, ln\, Y_{i,t} + \beta_{2,i}\, ln\, F\, T_{i,t} + \beta_{3,i}\, ln\, H\, K_{i,t} + \beta_{4,i}\, ln\, T\, O_{i,t} + \varepsilon_{i,t} \quad (5)$$

$$ln\, F\, T_{i,t} = \phi_0\, ln\, F\, T_{i,t-1} + \phi_{1,i}\, ln\, Y_{i,t} + \phi_{2,i}\, ln\, F\, DI_{i,t} + \phi_{3,i}\, ln\, H\, K_{i,t} + \phi_{4,i}\, ln\, E_{i,t} + \varepsilon_{i,t} \quad (6)$$

$$ln\, H\, K_{i,t} = \varphi_0\, ln\, H\, K_{i,t-1} + \varphi_{1,i}\, ln\, Y_{i,t} + \varphi_{2,i}\, ln\, F\, DI_{i,t} + \varphi_{3,i}\, ln\, F\, T_{i,t} + \varphi_{4,i}\, ln\, P\, OP_{i,t} + \varepsilon_{i,t} \quad (7)$$

Equation (4) assumes that foreign direct investment inflows (FDI), freight transport (FT), human capital (HK), capital stock (K) and inflation rate (I) are the main factors of economic growth (Y) (Nasreen et al., 2018; Magazzino, 2017; Qadri and Waheed, 2014).

Equation (5) postulates that FDI inflows can be affected by economic growth (Y), freight transport (FT), human capital (HK), and Trade openness (TO) (Canh, et al., 2020; Sirin, 2017; Liargovas and Skandalis, 2012; Pao and Tsai, 2010).

Equation (6) states that freight transport (FT) can be influenced by economic growth (Y), FDI inflows (FDI), human capital (HK), and energy consumption (E) (e.g., Sharif et al., 2019; Maparu and Mazumder, 2017; Chi, 2016; Lan et al., 2012).

Eq. (7), notes that economic growth (Y), foreign direct investment inflows (FDI), freight transport (FT) and population density (POP) can potentially affect human capital stock (HK) (Hana and Lee, 2020; Ono and Uchida, 2018; Völlmecke et al. 2016; Sulaiman et al. 2015; Liu and Yamauchi 2014).

3.2. Methodology and data

A large amount of literature has applied the time series approach to the panel modeling taking into account the various issues regarding non-stationarity, spurious regression and cointegration. In fact, the revision of unit root in empirical analysis of panel data has had an important role since the seminal works of Levin and Lin (1992) and Quah (1994). Researchers adopt two main generations of panel unit root tests to analyze the variables implemented in empirical surveys. The tests of Levin and Lin (1992), Levin et al. (2002), Harris and Tzavalis (1999), Im et al. (2003) and others constitute the first generation while the test of Phillips and Sul (2003), Pesaran (2003) and others constitute the second. The cross-sectional independence hypothesis is regarded as the major difference between the two generations. In fact, to apply the tests of the first generation, the assumption of cross section independence must be verified mandatorily, whereas second-generation considers the assumption of dependence.

To verify the cross-section dependence hypothesis, we execute the test of Pesaran (2004) and we calculate the CD statistics. The augmented Dickey–Fuller test calculates the average of coefficients of pair-wise correlation of OLS residuals for each individual unit. The cross-sectional independence is the null hypothesis following asymptotically a two-tailed standard normal distribution. Moreover, we present results of the semi-parametric Friedman test, as well as the parametric testing procedure proposed by Pesaran (2004) to check the assumption of cross-sectional independence in panel-data models with small T and large N. In the next step, we calculate the second generation panel unit root test (Pesaran, 2003) since the cross-section dependence assumption is verified and adopted. Following the null hypothesis we argue the existence of a unit root for all countries.

Moreover, we use the panel Ganger causality test to examine the causality direction among the different variables. Granger (1969) note that by using the Granger causality test we can verify whether one time series is capable of forecasting another. In fact, the Granger causality gives to economists a powerful tool for analyzing the causal impact and functional link from various panel data. To determine the optimal lag length in the Granger causality test, we adopt the ad-hoc selection technique of Jones (1989).

This study examines data from 25 African countries, covering the period 1995-2020, to observe the long-term causal relationships between FDI inflows, freight transport, human capital and economic growth. We consider 3 sub-panels as follows (a) 6 North African countries (NAC), namely, Algeria, Egypt, Libya, Mauritania, Morocco and Tunisia; (b) 9 Central African Countries (CAC), namely Burundi, Cameroon, the Central African Republic, Chad, Congo, the Democratic Republic of Congo, Equatorial Guinea, Gabon and São Tomé and Príncipe; and (c) 10 Southern African Countries (SAC), namely Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe. The selection of these countries is determined primarily by the availability of data. All data are from World Development Indicators (WDI, 2022).

The countries selected for empirical investigation are chosen due to the fact that empirical analysis in African countries is relatively rare. In addition, the three sub-groups have specific characteristics that are very suitable for the main objective of this case study. Indeed, the aptitudes

and skills of human capital are different according to regions and countries with different impacts on the attractiveness of FDI and economic growth. Moreover, we note the same characteristics for FDI; African countries are minor players in international investment movements. African participation in international trade is still limited despite the significant increase in recent years. UNCTAD (2022) reports that investment flows to Africa reached a record $83 billion in 2021.

Southern African countries are the biggest poles of attraction for FDI flows entering Africa. They receive more than $42 billion in 2022 while the volume is less than $4 billion in 2021. By contrast, FDI to North Africa declined by 5% to $9.3 billion in 2021. However, a significant 52% increase in the FDI inflows allows Morocco to receive $2.2 billion in 2022 while Egypt loses 12% of its FDI stock in 2021. Despite the decline, Egypt remains always the second-largest FDI recipient in the whole of Africa. For Central Africa, FDI flows remain stable between 2021 and 2022 at around $9.4 billion. The Democratic Republic of Congo recorded an increase of 14% while Congo, on the contrary, recorded a decrease of 8% for the same period. In addition, we found that the transport is very important for the economic activity in the developing countries and affects strongly the territorial attractiveness. However, in the African countries the transport networks are underdeveloped and need deep transformation. In fact, the road is the main mode of transport in Africa. As stated in several studies, the road networks ensure 80 to over 90% of freight traffic. In addition, we find that the African railway network is currently the least developed with more than fifteen countries that do not have a railway. By taking into account the large difference in characteristics of different sub-panels, we choose to study simultaneously the FDI and its relationship with the transport and human capital accumulation and investigate their consequences for economic development in the different countries.

During the empirical investigation, we use several variables such as economic growth measured by real GDP (Y; constant 2010 US$), foreign direct investment inflows received by the host country (FDI; constant 2010$),

Table-2. Description and measurement of variables

Variable	Description	Measurement	Source
Y	Real gross domestic product	Constant 2010 US$	WDI (2022) *
FDI	Foreign direct investment net inflows	Constant 2010 US$	WDI (2022) *
FT	freight transportation	ton-kilometers	WDI (2022) *
HK	human capital accumulation	enrolment ratio, secondary both sex (%) + gross enrolment ratio, tertiary both sexes (%)	WDI (2022) *
K	Capital stock	Constant 2010 US$	WDI (2022) *
E	Energy consumption	kg of oil equivalent	WDI (2022) *
TO	trade openness	imports and exports constant 2010$	WDI (2022) *
POP	population density	people per sq.km of land area	WDI (2022) *
I	Inflation	Consumer price index	WDI (2022) *

*https://databank.worldbank.org/

freight transportation (FT; measured by ton-kilometers), human capital accumulation (HK; measured as enrolment ratio, secondary both sex (%) + gross enrolment ratio, tertiary both sexes (%), energy consumption (E; kg of oil equivalent), population density (POP; people per sq.km of land area), inflation (I; consumer price index), capital stock (K; constant 2010$), trade openness (TO; imports and exports constant 2010$). The data collected, spanning the period from 1995 to 2020, has been sourced from the World Bank's World Development Indicators (WDI, 2022). The empirical study was conducted using the EViews-11 software. Descriptions, measurements, and sources of the variables are detailed in Table-2 below.

Based on the main assumptions of endogenous growth, long-run economic growth should be based on the accumulation of human capital (Lucas 1988; Romer 1986, 1990; Pigalle 1994; Rajhi 1996), public capital (Aschauer 1989; Barro 1990), physical capital (Romer, 1986) and technological capital (Romer 1986; Pissarides 1997). Barro's (1990) model studied the influence of public capital accumulation on growth and in the functioning of both multinational and domestic firms. Indeed, he discussed the particular role of basic and transport infrastructures in sustaining global economic activity over long periods. Inspired by the basic model of Barro (1990), several researchers have tried to validate the significant contribution of transport systems to economic growth taking into account the positive impact on the territorial attractiveness of FDI (Saidi and Mefteh, 2020; Maparu and Mazumder, 2017; Pradhan et al. 2016; Magazzino and Valeri, 2012; Marazzo et al. 2010). In the same vein, we examine the causalities between the entry of FDI and the accumulation of public capital (transport system) and human capital (enrollment in secondary and tertiary education). For public capital, we choose to use the freight transport indicator by referring to the total movement of goods. Data are expressed in millions of tonne-kilometers, which represents the transport of one tonne in one kilometer.

The statistics in Table-3 below show the descriptive statistics of the variables introduced in the four equations above. The normal distribution is well confirmed since the mean and median are close. The Jarque-bera statistics also prove that the variables are normally distributed. The coefficients of skewness are negative indicating that the distribution is skewed to the left. However, the population is skewed to the right. The IQR results confirm the absence of outliers.

4. Empirical Results

The empirical investigation starts by the cross-sectional dependence analysis to improve the quality of econometric modeling with panel data. Indeed, the independence of the error term by the cross section is a standard hypothesis which must be satisfied. In this study, we found that the cross-sectional independence hypothesis cannot be accepted since the null hypothesis is rejected at the significance level of 5% (Table-4).

The next step involves addressing cross-sectional dependence. Indeed, the normal DF (or ADF) regressions are enhanced with the cross-section means of lagged levels and first-differences of the individual series (CADF statistics). By controlling for cross-sectional dependence, the previous results are confirmed (Table-5). In fact, the hypothesis that all series are stationary at the first difference is validated.

Table-3. Descriptive Statistics (before taking logarithm)

	Mean	Median	SD	Skewness	Kurtosis	IQR	J-B
Y	171,606	159,593	217,322	-0,288	3,972	0,725	3,929
FDI	50,870	47,309	286,976	-0,383	3,649	0,652	3,846
FT	53,898	50,125	10,001	-1,036	2,512	1,590	5,373
HK	227,145	211,244	80,516	-1.526	3.554	0.956	4,551
K	335,486	312,001	15,928	-0,646	3,141	1,316	2,889
E	250,761	233,207	144,124	-1,020	2,673	1,157	2,308
TO	202,96	188,752	61,957	-1,541	4,229	0,910	2,932
POP	16,854	15,674	10,433	0,487	3,020	1,511	3,028
I	68,542	63,744	27,149	-1,130	2.860	1,056	2,309

Table-4. Cross-Sectional Dependence Analysis

	1	2	3
lnY_t	44.1384 (0.0000)	36.4559 (0.0000)	176.1617 (0.0000)
$lnFDI_t$	55.1631 (0.0000)	50.7628 (0.0000)	231.162 (0.0000)
$lnFT_t$	49.9588 (0.0000)	42.2930 (0.0000)	179.4646 (0.0000)
$lnHK_t$	66.1636 (0.0000)	57.3703 (0.0000)	184.2600 (0.0000)
lnE_t	45.9657 (0.0000)	30.8016 (0.0000)	160.3228 (0.0000)
lnK_t	43.7228 (0.0000)	51.4153 (0.0000)	208.0630 (0.0000)
$lnPOP_t$	40.8375 (0.0000)	44.1702 (0.0000)	195.3410 (0.0000)
$lnTO_t$	46.3749 (0.0000)	42.8524 (0.0000)	161.9858 (0.0000)
lnI_t	43.8307 (0.0000)	46.5829 (0.0000)	182.7699 (0.0000)

Notes: Pesaran (2004) cross-sectional dependence in panel data models test. Pesaran (2004) CD test for cross-sectional dependence in panel time-series data. Friedman test for cross-sectional dependence using Friedman's χ2distributed statistic. P-values in parentheses. Tests include the intercept.

Table-5. Unit Root Analysis with Cross-Sectional Dependence

Variable	Constant	Constant and trend
lnY_t	-6.5162 (0.0000) ***	-7.9924 (0.0000) ***
$lnFDI_t$	-2.8004 (0.0217) **	-5.3622 (0.0038) ***
$lnFT_t$	-7.7974 (0.0000) ***	-8.34015 (0.0000) ***
$lnHK_t$	-3.2364 (0.0177) **	-5.0453 (0.0012) ***
lnE_t	-5.4070 (0.0030) ***	-6.9890 (0.0023) ***
lnK_t	-3.2364 (0.0183) **	-4.6572 (0.0015) ***
$lnPOP_t$	-4.6163 (0.0121) **	-4.7893 (0.0014) ***
$lnTO_t$	-4.8115 (0.0115) **	-5.0498 (0.0011) ***
lnI_t	-6.0175 (0.0021) ***	-6.6632 (0.0001) ***

Notes: P-values in parentheses, ***, **significant at 1% and 5%levels respectively.

To ameliorate the value of our results and interpretations, we should ensure the consistency in the outcomes that transmissions and feedbacks occur between the variables.

The Granger causality test is used to define the nature of diverse relationships between the main series. The results of causality test (Table-6) note that the causalities between EG and FDI is positive and bidirectional for global panel and sub-panels. Likewise, feedback causality is founded between growth and freight transportation as well as between growth and human capital stock for all selected countries. The results also indicate that the causality among FDI and FT is bidirectional for the global panel and CAC panel and unidirectional, running from FDI to FT for the SAC and NAC panels. Another feedback effect is detected between FDI and HK for the global panel and NAC panel. In addition, the outcome exposed a one-way causality passing from FDI to HK for the SAC and CAC.

Table-6. Panel Granger causality results

Null Hypothesis	F-statistics.	Prob.
25 African countries		
Y does not homogeneously cause FDI	3.9300	0.0000
FDI does not homogeneously cause Y	4.6295	0.0000
Y does not homogeneously cause FT	3.6482	0.0000
FT does not homogeneously cause Y	4.1185	0.0000
Y does not homogeneously cause HK	3.2488	0.0034
HK does not homogeneously cause Y	3.6348	0.0000
FDI does not homogeneously cause FT	3.2580	0.0030
FT does not homogeneously cause FDI	4.4079	0.0000
FDI does not homogeneously cause HK	4.9964	0.0000
HK does not homogeneously cause FDI	2.9589	0.0040
FT does not homogeneously cause HK	1.3569	0.0560
HK does not homogeneously cause FT	0.5124	0.0876
South African countries		
Y does not homogeneously cause FDI	4.5101	0.0000
FDI does not homogeneously cause Y	4.0122	0.0000
Y does not homogeneously cause FT	5.7162	0.0000
FT does not homogeneously cause Y	5.1428	0.0000
Y does not homogeneously cause HK	3.9456	0.0000
HK does not homogeneously cause Y	3.6188	0.0000
FDI does not homogeneously cause FT	4.0074	0.0000
FT does not homogeneously cause FDI	0.9488	0.0712
FDI does not homogeneously cause HK	3.1483	0.0038
HK does not homogeneously cause FDI	1.0511	0.0622

Null Hypothesis	F-statistics.	Prob.
FT does not homogeneously cause HK	0.7485	0.0811
HK does not homogeneously cause FT	0.5528	0.0870
North African countries		
Y does not homogeneously cause FDI	4.0018	0.0000
FDI does not homogeneously cause Y	3.7427	0.0000
Y does not homogeneously cause FT	4.2946	0.0000
FT does not homogeneously cause Y	3.6428	0.0000
Y does not homogeneously cause HK	5.6249	0.0000
HK does not homogeneously cause Y	3.2647	0.0009
FDI does not homogeneously cause FT	3.3460	0.0006
FT does not homogeneously cause FDI	0.4140	0.0917
FDI does not homogeneously cause HK	3.3360	0.0007
HK does not homogeneously cause FDI	3.6284	0.0000
FT does not homogeneously cause HK	1.0034	0.0652
HK does not homogeneously cause FT	0.6942	0.0846
Central African countries		
Y does not homogeneously cause FDI	3.6270	0.0000
FDI does not homogeneously cause Y	3.4188	0.0005
Y does not homogeneously cause FT	3.6255	0.0000
FT does not homogeneously cause Y	3.6002	0.0000
Y does not homogeneously cause HK	4.2462	0.0000
HK does not homogeneously cause Y	3.8568	0.0000
FDI does not homogeneously cause FT	3.9672	0.0000
FT does not homogeneously cause FDI	4.1389	0.0000
FDI does not homogeneously cause HK	3.4869	0.0003
HK does not homogeneously cause FDI	0.3148	0.0942
FT does not homogeneously cause HK	0.9468	0.0715
HK does not homogeneously cause FT	0.9654	0.0701

Notes: The lag length of all variables is 1.

4.1. The FMOLS and DOLS Estimations

Upon establishing co-integration among variables, it becomes imperative to ascertain the long-run elasticities through specific co-integration estimators. Pedroni (2004) introduced various estimators, such as ordinary least squares (OLS), fully modified ordinary least squares (FMOLS), and dynamic ordinary least squares (DOLS) to explore the enduring relationships among co-integrated variables.

The ordinary least squares method calculates the estimated cointegrated vector, displaying remarkable convergence for both

time series and panel data. To address endogeneity issues concerning serial correlations and regressors in error terms, the FMOLS and DOLS methods are employed. The fully modified ordinary least squares estimators utilize a non-parametric approach to tackle autocorrelation and endogeneity problems. Conversely, the dynamic ordinary least squares approach incorporates both lags and leads of explanatory variables to rectify endogeneity in regressors (Kao and Chiang, 2000; Kumar and Smyth, 2007).

Moreover, Danish et al. (2019) and Dogan and Seker (2016) argue that in cases with small sample sizes, DOLS estimators demonstrate greater efficiency, providing unbiased, efficient, and consistent estimates. Similarly, Danish et al. (2019) and Dogan and Seker (2016) highlight that the weighted criteria of DOLS and FMOLS methods effectively manage heterogeneity in the long-run variance and cointegrated panel.

In the current empirical study, the Full-Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) estimators yield highly comparable results. Detailed results for both the overall panel and the three sub-groups are provided in Tables 7 and 8.

The results relating to equations (4) and (5) obtained using the FMOLS and DOLS estimators are shown in Table-7 above. For the global panel (25 countries), the economic development of the countries depends largely and positively on the entry of FDI, freight transportation and human capital and capital stock. In Africa, the GDP increases by 0.264%, 0.220%, 0,199% and 0.236% if these variables augment respectively by 1% per year. The impact of inflation is negative and significant at 1% threshold (-0.263). These results come in line with those of Zhu et al., (2020) for China; Rahman and Vu (2020) for Australia and Canada, Teixeira and Queirós (2016) for 21 OCDE countries; Su and Nguyen (2022) for 38 African countries. On the contrary, they oppose the conclusions of Muller (2021) who found a negative impact of FDI on economic development in 47 sub-Saharan countries between 1996 and 2017. In the same vein, we found that the results of DOLS are close to those of the FMOLS. Similarly, a positive and statistically significant effect is observed for the transportation and capital. The magnitude of 0.209 and 0.214 implies that the GDP augments by 0.209% and 0.214% if the two variables increase by 1% respectively. Also, the FDI and HK have a positive influence on the economic development which is statistically significant at 1% and 10% respectively. The significant and negative impact of inflation is again confirmed by the DOLS estimators. For the 25 African economies, GDP declines by 0.260% when the inflation rate increases periodically by 1%.

For the Southern African countries (SAC), the GDP depends strongly on the FDI entry and transportation of goods. A magnitude of 0.220 means that if the foreign direct investment stock in the recipient countries increases by 1%, the economic growth augments by 0.220%. Also, if the volume of transported freight rises by 1%, the gross domestic product in the Southern African countries increases by 0.290%. For the human capital stock, the effect on GDP is now positive but statistically insignificant (0.0025). Equally in the global panel, the influence of capital and inflation is statistically significant. Indeed, the capital affects positively the economic growth while the effect of inflation remains negative. The results of both FMOLS and DOLS estimators are very similar and allow us to obtain the same conclusions for the Southern African

Table-7. Panel DOLS and panel FMOLS results for Eqs. (4) and (5)

Model 1			Dependent variable: economic growth (Y)	
	FMOLS		DOLS	
	Coefficients	p-value	Coefficients	p value
25 African countries				
ln FDI	0.2641	(0.0085)***	0.2508	(0.0093)***
ln FT	0.2206	(0.0216)**	0.2095	(0.0266)**
ln HK	0.0199	(0.0703)***	0.0189	(0.0985)*
ln K	0.2365	(0.0103)**	0.2146	(0.0255)**
ln l	-0.2633	(0.0088)***	-0.2601	(0.0091)***
South African countries				
ln FDI	0.2201	(0.0245)**	0.1991	(0.0272)**
ln FT	0.2901	(0.0020)***	0.2864	(0.0038)***
ln HK	0.0025	(0.2985)	-0.002 4	(0.3304)
ln K	0.2321	(0.0160)**	0.2332	(0.0169)**
ln l	-0.2300	(0.0174)**	-0.2215	((0.0203)**
North African countries				
ln FDI	0.2464	(0.0096)***	0.2340	(0.0133)**
ln FT	0.1192	(0.0526)*	0.1132	(0.0546)*
ln HK	0.2225	(0.0192)**	0.0074	(0.2584)
ln K	0.1607	(0.0402)**	0.3200	(0.0000)***
ln l	-0.2728	(0.0062)***	-0.2700	(0.0073)***
Central African countries				
ln FDI	0.3389	(0.0000)***	0.3219	(0.0000)***
ln FT	0.1093	(0.0623)**	0.1150	(0.0533)*
ln HK	0.1403	(0.0515)**	0.1380	(0.0517)*
ln K	0.2924	(0.0004)***	0.2778	(0.0045)***
ln l	-0.2524	(0.0092)***	-0.2657	(0.0081)***

Model 2			Dependent variable: FDI inflows (FDI)	
	FMOLS		DOLS	
	Coefficients	p value	Coefficients	p value
25 African countries				
ln Y	0.2894	(0.0028)***	0.3023	(0.0000)***
ln FT	0.2779	(0.0044)***	0.2761	(0.0054)***
ln HK	0.1867	(0.0304)**	0.1789	(0.0352)**
ln TO	0.3614	(0.0000)***	0.3433	(0.0000)***
South African countries				
ln Y	0.3412	(0.0000)***	0.3241	(0.0000)***
ln FT	0.2279	(0.0178)**	0.2267	(0.0180)**
ln HK	0.2871	(0.0033)***	0.2724	(0. 0065)***
ln TO	0.3397	(0.0000)***	0.3576	(0.0000)***
North African countries				
ln Y	0.2742	(0.0056)***	0.2604	(0.0090)***
ln FT	0.2935	(0.0002)***	0.2789	(0.0041)***
ln HK	0.1108	(0.0566)*	0.1053	(0.0680)*
ln TO	0.3059	(0.0000)***	0.2906	(0.0017)***
Central African countries				
ln Y	0.3654	(0.0000)***	0.3471	(0.0000)***
ln FT	0.2846	(0.0039)***	0.2721	(0.0070)***
ln HK	0.1350	(0.0518)*	0.1485	(0.0513)*
ln TO	0.3422	(0.0000)***	0.3614	(0.0000)***

***, **,* significant at 1%, 5%, 10% levels respectively

countries representing the most attractive countries in our current study.

Regarding the statistics of the North African countries (NAC), we found that the impacts of FDI, HK, and FT are important with different levels of significance. The coefficients of 0.246; 0.222 and 0.119 mean that the North African economies acknowledge an important increase in their GDP if the mentioned variables increase by 1 respectively (0.246%, 0.222%, and 0.119%). These results reject those of Hamdi et al. (2013), who found that the impact of FDI inflows on Tunisian economic growth is insignificant. Otherwise, the same results are in line with the conclusions of Acikgoz and Ben Ali (2019), who confirm a strong relationship between economic growth and human capital stock in the Middle Eastern and North African countries. The capital and inflation rate affect significantly the economic development in the 6 North African countries. However, the impact of capital is positive (0.1607) while the impact of the inflation rate is negative (-0.2728). The results are in line with those of Khan et al. (2020) for 6 countries; Salahuddin et al. (2015) for Gulf Cooperation Council Countries. For the central African countries, we found that they have similar results as North African countries with the exception of the impact of FT and HK which are significant at 10% and 5% levels respectively. The impact of capital is positive and significant at 1% level indicating that a 1% increase in the capital stock leads to economic growth by 0.292 % (FMOLS) and 0.277% (DOLS). For the inflation rate, the impact remains always negative and significant at 1% level.

In model 2, the two methods provide similar results for each variable in terms of sign and significance. Considering the total panel, we note that an increase by 1% in the economic growth, freight transportation, and human resources has a positive effect on foreign direct investment inflows. Indeed, the FDI stock in host countries augments by 0.289%, 0.186%, and 0.277% if the economic growth, human capital and freight transport increase by 1% respectively. Also, the results prove that the trade openness can increase the FDI entry by 0.361% if it increases by 1%. Based on the statistics of the DOLS estimators, the results are very close to those of the FMOLS estimators. Our results are largely confirmed by several previous studies; Canh, et al. (2020) for 21 economies, Asongu and Odhiambo (2020) for 25 Sub-Saharan countries. The impacts of economic growth and freight transport are always the same in term of sign and significance. In fact, the FDI stock in a recipient country increases by 0.289% and 0.277% (FMOLS) and 0.302% and 0.276% (DOLS) if there is an augmentation by 1% in GDP and FT respectively. Nevertheless, the impacts of HK and TO are positive and statistically significant at 5% and 1% respectively.

For the three sub-groups, the statistics of the two estimators are slightly different from each other. In the countries of the South African region, the statistics established show that the economic growth and human capital stock determine strongly the volume of entering FDI. The FMOLS estimators give the magnitude of 0.341 and 0.287 indicating that the FDI inflows increase by 0.341% and 0.287% if the GDP and HK increase by 1% respectively (Kottaridi et al., 2019; Stack et al., 2017). In addition, the FDI attractiveness is affected by the trade openness and the freight transport at 1% and 5% levels. These results are largely confirmed by those obtained by the DOLS estimators. Economic growth and the stock of human capital remain among the most important determinants of

the attractiveness of FDI. Despite the slight decrease, the impact of the two variables is still positive and significant at 1%. Similarly, trade openness and freight transport keep the positive and significant effect. The high dependence of FDI inflows on EG, HK, FT and TO is consistent with the findings of Halaszovich and Kinra, (2018); Saidi, (2016).

In the North African countries (NAC), the FDI inflows are positively affected by economic growth, human capital, freight transport and trade openness. For the FMOLS tests, the impact is significant at 1% for the economic growth, freight transport and trade openness and at 10% for the human capital. The coefficients of 0.274, 0.293 and 0.305 maintain that FDI stocks in the NAC increase by 0.274%, 0.293% and 0.305% if the economic growth, the transportation of goods and the trade openness increase by 1% respectively. In addition, the statistics show that the FDI stock increases by 0.110% when the human capital stock in the recipient economies increase by 1%. The DOLS results indicate that the effect of transportation and human resources declines slightly while the economic growth and trade openness have the same importance as major factors FDI attractiveness. Coefficients of 0.278 and 0.105 imply that the FDI stock in the countries of North Africa augments by 0.278% and 0.105% if the freight transportation and human capital augment by 1% respectively.

In the central African countries (CAC), FDI inflows are also mainly determined by the economic development, freight transportation and trade openness at 1% level of significance for the FMOLS, except the human capital stock which has an influence significant at 10% level. The same findings are given by the DOLS estimators. An augmentation by 0.347%, 0.272% and 0.361% are potential in the FDI stocks if there is an increase by 1% in the economic development, cargo transportation and trade openness in the Central African countries. The impact of the human capital is positive at a 10% level of significance. A magnitude of 0.148 implies that a 1% increase in the human capital augments the FDI stock by 0.148% in the CAC.

Table-8 above contains the statistics of the models where we consider the freight transportation and human capital as endogenous variables. In equation 6 above, the freight transportation is founded mainly influenced by the economic growth, FDI stock, and energy use in the 25 African countries selected for the empirical investigation. FMOLS as well as DOLS estimators show that the 1% increase in GDP, FDI and energy use causes an increase in the volume of transported freight by 0.356%, 0.188%, and 0.027% (FMOLS) and 0.349%, 0.185%, and 0.0267 % (DOLS). Moreover, similar results were found in the Southern African panel. The effect is positive and statistically significant at 1% for the GDP and energy demand and at 5% for FDI inflows (FMOLS and DOLS). Likewise, the results prove that the human capital has a positive and significant impact on the freight transportation in the global panel and southern African region. Ewbank et al., (2019); Bektas et al., (2019) and Cole et al. (2011) found similar results and conclusions.

For the North African and Central African panels, positive and significant impacts at 1% and 5% levels of significance are observed for the economic growth, FDI inflows and energy demand. However, the impact of human capital stock is insignificant. The statistics in table-8 show that in NAC and CAC panels, a 1% increase in the GDP leads to increases in the volume of transported goods by 0.358% and 0.403% for the FMOLS results and by 0.351%

Table-8. Panel DOLS and panel FMOLS results for Eqs. (6) and (7)

Model 3	Dependent variable: freight transport (FT)			
	FMOLS		DOLS	
	Coefficients	p-value	Coefficients	p value
25 African countries				
ln Y	0.3564	(0.0010)***	0.3492	(0.0025)***
ln FDI	0.1889	(0.0246)**	0.1852	(0.0245)**
ln HK	0.0272	(0.1410)	0.0267	(0.1458)
ln E	0.3648	(0.0020)***	0.3575	(0.0008)***
South African countries				
ln Y	0.3486	(0.0030)***	0.3500	(0.0020)***
ln FDI	0.2212	(0.0103)**	0.2167	(0.0125)**
ln HK	0.1707	(0.0533)*	0.1673	(0.0546)*
ln E	0.3454	(0.0038)***	0.3384	(0.0044)***
North African countries				
ln Y	0.3581	(0.0006)***	0.3515	(0.0016)***
ln FDI	0.2050	(0.0172)**	0.2044	(0.0182)**
ln HK	0.0039	(0.3004)	0.0043	(0.2985)
ln E	0.3462	(0.0028)***	0.3393	(0.0039)***
Central African countries				
ln Y	0.4032	(0.0000)***	0.3707	(0.0000)***
ln FDI	0.2004	(0.0201)**	0.1947	(0.0216)**
ln HK	0.0060	(0.2584)	0.0066	(0.1985)
ln E	0.4528	(0.0000)***	0.4166	(0.0000)***

Model 4	Dependent variable: Human capital accumulation (HK)			
	FMOLS		DOLS	
	Coefficients	p value	Coefficients	p value
25 African countries				
ln Y	0.3297	(0.0054)*	0.3132	(0.0056)***
ln FDI	0.3829	(0.0000)*	0.3637	(0.0004)***
ln FT	0.1777	(0.0304)**	0.1741	(0.0526)*
ln POP	0.2118	(0.0164)**	0.2161	(0.0155)**
South African countries				
ln Y	0.3388	(0.0041)*	0.3457	(0.0033)***
ln FDI	0.3719	(0.0000)***	0.3533	(0. 0014)***
ln FT	0.1837	(0.0282)**	0.1745	(0.0501)*
ln POP	0.2192	(0.0133)**	0.2016	(0.0196)**
North African countries				
ln Y	0.3187	(0.0054)***	0.3124	(0.0062)***
ln FDI	0.2602	(0.0092)***	0.2645	(0.0088)***
ln FT	0.0029	(0.3053)	0.0030	(0.3010)
ln POP	0.1294	(0.0566)*	0.1266	(0.0623)*
Central African countries				
ln Y	0.3477	(0.0027)***	0.3104	(0.0081)***
ln FDI	0.2426	(0.0096)***	0.2551	(0.0093)***
ln FT	0.0023	(0.3066)	0.0019	(0.3084)
ln POP	0.0129	(0.1552)	0.0126	(0.1745)

***, **,* significant at 1%, 5%, 10% levels respectively

and 0.370 for the DOLS results. Furthermore, for the Central African panel, a 1% increase in FDI stock enhances the freight transport by 0.200% for the FMOLS model and 0.194% for the DOLS model. The same impact is more important in the North African countries where the freight transport may augment by 0.205% and 0.204% if the FDI inflows increase by 1% according to the statistics of FMOLS and DOLS respectively. Also, the two approaches confirm a positive impact of energy use in the Central and North African countries. Indeed, the FMOLS note that a 1% increase in the energy demand augments the freight transport by 0.452% and 0.346% while the statistics of DOLS prove an augmentation by 0.416% and 0.339% respectively. Finally, for the human capital an insignificant relationship is proved by the FMOL and DOLS.

Regarding model 4; human capital is the dependent variable, the DOLS and FMOLS methods give results that confirm the significant relationship between economic growth, FDI inflows, population density and human capital for the global as well as for the three sub-panels. The same statistics confirm the absence of significant causality between human capital accumulation and freight transport for all studied panels. For the total panel, the human capital accumulation depends on the GDP growth and FDI entry at a 1% level. Indeed, a 1% increase in the EG and FDI raises the stock of human resources by 0.329% and 0.382% (FMOLS) and 0.313% and 0.363% (DOLS) respectively. Similar results are given for the Southern African countries. The positive relationship between economic growth, FDI inflows and human capital accumulation are largely confirmed by various theoretical and empirical works (Bucci et al., 2019; Xu and Li, 2019; Su and Liu, 2016; Pelinescu, 2015). Additionally, the human capital seems positively impacted by the population density but the effect is significant at 5% for the global panel and Southern African countries. In fact, the human capital increases by 0.211% and 0.219% (FMOLS) and by 0.2016% and 0.201% (DOLS) when there is an augmentation on population density by 1% in the global panel and South African countries.

Concerning the results of the North and Central African regions, the calculated coefficients of economic growth and FDI stock on human capital accumulation are statistically significant at 1%. The FMOLS estimators show that the human capital stock in the two regions increases by 0.318%, 0.260%, 0.347% and 0.242% if the GDP and FDI, inflows augment by 1% respectively. Also, the statistics of DOLS estimators are similar since an augmentation by 1% in the two variables improves the human capital by 0.312%, 0.264%, 0.310%, 0.255%, in the central African countries. These results are in line with those of Ranis et al. (2000) for 76 developing countries and Völlmecke et al. (2016) for the European regions. Furthermore, population density positively affects the human capital in North African countries at a 10% level. This suggests that a 1% increase in POP leads to an increase in the stock of human resources by about 0.129% in the FMOLS model and 0.126% in the DOLS model. By contrast, in the central African countries the human capital accumulation and population density are weakly inter-correlated in the long-run. Similarly to the findings of the total panel and South African countries, we found that the links are insignificant between human capital stock and freight transport in the North African region.

4.2. Robustness analyses

To assess the robustness of our main results, we conducted a robustness analysis. We re-estimated the regressions, taking into account the dynamic effect of the variables used. In fact, we employed dynamic panel data models in simultaneous equations, where lagged levels of economic growth, foreign direct investment (FDI), freight transportation (FT), and human capital (HK) are considered using the GMM estimator by Arellano and Bond (1991). The empirical models to be estimated can be reformulated as follows:

$$ln\,Y_{i,t} = \alpha_0\,ln\,Y_{i,t-1} + \alpha_{1,i}\,ln\,FDI_{i,t} + \alpha_{2,t}\,ln\,FT_{i,t} + \alpha_{3,i}\,ln\,HK_{i,t} + \alpha_{4,i}\,ln\,K_{i,t} + \alpha_{5,i}\,ln\,I_{i,t}\,\varepsilon_{i,t} \quad (4)$$

$$ln\,FDI_{i,t} = \beta_0\,ln\,FDI_{i,t-1} + \beta_{1,i}\,ln\,Y_{i,t} + \beta_{2,i}\,ln\,FT_{i,t} + \beta_{3,i}\,ln\,HK_{i,t} + \beta_{4,i}\,ln\,TO_{i,t} + \varepsilon_{i,t} \quad (5)$$

$$ln\,FT_{i,t} = \phi_0\,ln\,FT_{i,t-1} + \phi_{1,i}\,ln\,Y_{i,t} + \phi_{2,i}\,ln\,FDI_{i,t} + \phi_{3,i}\,ln\,HK_{i,t} + \phi_{4,i}\,ln\,E_{i,t} + \varepsilon_{i,t} \quad (6)$$

$$ln\,HK_{i,t} = \varphi_0\,ln\,HK_{i,t-1} + \varphi_{1,i}\,ln\,Y_{i,t} + \varphi_{2,i}\,ln\,FDI_{i,t} + \varphi_{3,i}\,ln\,FT_{i,t} + \varphi_{4,i}\,ln\,POP_{i,t} + \varepsilon_{i,t} \quad (7)$$

Furthermore, one of the main challenges hindering the use of FMOLS or DOLS is the correlation between lagged endogenous variables ($Y_{i,t-1}$; $FDI_{i,t-1}$; $FT_{i,t-1}$; $HK_{i,t-1}$) and the error term. Several researchers have employed the Arellano and Bond (1991) approach to address this issue through first differencing, significantly enhancing the quality of their results. Additionally, we have observed that GMM estimation can be utilized to assess the robustness of our conclusions, as it offers various advantages over the FMOLS or DOLS. Firstly, panel data, combining cross-sectional and time-series data, allows for estimating relationships over an extended period and across multiple countries. The GMM estimator is simpler compared to the maximum likelihood estimator. Secondly, any country-specific effect can be controlled using an appropriate GMM procedure. The GMM estimator provides robust empirical results without the need for precise information on the distribution of the error term. Thirdly, to ensure the robustness of the estimation, it is essential to employ the approach introduced by Arellano and Bond (1991), which resolves the issue through first differencing. Moreover, GMM provides an unbiased and reliable estimator without resorting to matrix weighting.

In fact, to assess the robustness of the results, we use the generalized method of moments (GMM) to simultaneously estimate the four equations (8-11). This methodology proves effective even in the presence of arbitrary heteroskedasticity, providing consistent and efficient estimates that reveal the varied relationships among the variables in our models. The results presented in Tables 9 and 10 below demonstrate that the findings are very similar to those obtained with the FMOLS and DOLS estimators. As indicated in Table 8, the results derived from lagged data exhibit a pattern very akin to the original multiple regression results presented in equations 4 to 7.

5. Conclusion and policy implications

In the context of this study, we employed FMOLS and DOLS estimators, to scrutinize the enduring associations among foreign direct investments (FDI), human capital accumulation (HK), freight transportation (FT), and economic growth (Y). The empirical exploration spans a quarter-century, encompassing the years 1995 to 2020, and focuses on 25 African countries distributed across three distinct regions: Southern Africa, Central Africa, and North Africa. The primary findings reveal that, on the whole, the long-term relationships exhibit bidirectionality with positive correlations in both directions. However, certain connections display unidirectionality with marginal statistical significance, such as the linkage between FDI and HK in the Southern and Central African regions. Additionally, it is noteworthy that no significant relationships were observed between FT and HK in all examined cases.

These findings underline the complexity of the relationships among FDI, HK, FT, and economic growth in the African context.

Table 9. GMM Analysis for the 25 African and South African countries

	25 African countries				South African countries			
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Independent Variable	**Y_t**	**FDI_t**	**FT_t**	**HK_t**	**Y_t**	**FDI_t**	**FT_t**	**HK_t**
Y_t		0.2884 (0.0000) ***	0.3271 (0.0000) ***	0.2618 (0.0000) ***		0.3102 (0.000)***	0.3140 (0.0000) ***	0.3133 (0.000) ***
FDI_t	0.2501 (0.0004) ***		0.1698 (0.0424)**	0.3271 (0.0000) **	0.3015 (0.0056) ***		0.2011 (0.048) **	0.3370 (0.000) ***
FT_t	0.2480 (0.0032)**	0.2960 (0.0000)***		0.1706 (0.0547) *	0.3074 (0.0050) ***	0.2610 (0.0018) ***		0.1771 (0.059) *
HK_t	0.0181 (0.1317)	0.1698 (0.0510)*	0.0231 (0.2062)		0.0096 (0.2705) **	0.3251 (0.000) ***	0.1552 (0.070) *	
K_t	0.1989 (0.0205) **				0.2019 (0.020) **			
I_t	-0.3120 (0.0000) ***				-0.1910 (0.025) ***			
TO_t		0.3014 (0.0000) ***				0.3352 (0.001) **		
E_t			0.2140 (0.0148)**				0.3100 (0.000) ***	
POP_t				0.2014 (0.0283) **				0.1992 (0.046) **
Constant	0.5002 (0.0000) ***	0.3298 (0.0000) ***	0.3440 (0.0000) ***	0.5380 (0.0000) ***	0.3004 (0.0000) ***	0.2799 (0.000) ***	0.3118 (0.00) ***	0.4112 (0.00) ***
Hansen J-test (p-value)	37.0012 (0.177)	30.1224 (0.330)	17.2011 (0.344)	33.6927 (0.247)	27.00 (0.3988)	17.63 (0.516)	29.14 (0.369)	22.48 (0.411)
AR2 test (p-value)	0.688 (0.684)	0.641 (0.712)	0.521 (0.679)	0.606 (0.604)	0.077 (0.302)	0.711 (0.522)	0.282 (0.750)	0.652 (0.438)

Notes: Values in parenthesis are the estimated p-values. The Sargan test refers to the over-identification test for the restrictions in the GMM estimation. The AR (2) test is the Arellano-Bond test for the existence of the second-order autocorrelation in first differences. ***,**and * significant at 1%, 5% and 10% levels respectively

The bidirectional and positive long-term relationships suggest a mutually reinforcing dynamic between these variables, signaling potential synergies that could contribute to sustainable economic development. However, the unidirectional linkages and the absence of significant relationships in certain cases highlight the need for region-specific policy considerations and interventions. Addressing the nuances of these relationships can assist policymakers in tailoring strategies that capitalize on positive interactions while mitigating challenges specific to each region, fostering a more targeted and effective approach to economic development in Africa.

Moreover, our analysis brings to light nuanced regional variations in the identified relationships. In Southern Africa, the bidirectional link between FDI and HK, though statistically significant, suggests an important impact of foreign investments on human capital accumulation. Similarly, in North Africa, this relationship shows a more substantial and bidirectional character, emphasizing a reciprocal influence between foreign direct

Table 10. GMM Analysis for the North African and Central African countries

	North African countries				Central African countries			
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Independent Variable	Y_t	FDI_t	FT_t	HK_t	Y_t	FDI_t	FT_t	HK_t
Y_t		0.2593 (0.0025) ***	0.3260 (0.0000) ***	0.2808 (0.0071) ***		0.3359 0.000) ***	0.4027 (0.000) ***	0.3135 (0.000) ***
FDI_t	0.2290 (0.0209) **		0.1879 (0.043) **	0.2413 (0.018) **	0.3159 (0.000) ***		0.1894 (0.0295) **	0.4553 (0.000) ***
FT_t	0.1084 (0.0620) *	0.2679 (0.0000) ***		0.2901 (0.0015) ***	0.1042 (0.0510) *	0.2774 (0.001) ***		0.0083 (0.366)
HK_t	0.2150 (0.0283) **	0.1218 (0.061) *	0.0035 (0.2974)		0.1318 (0.043) **	0.1422 (0.049) **	0.0053 (0.2250)	
K_t	0.193 (0.047) **				0.2982 (0.000) ***	0.3286 (0.000) ***		
I_t	-0.2483 (0.003) ***				-0.2629 (0.002) ***			
TO_t		0.2626 (0.002) ***				0.2991 (0.004) ***	0.3349 (0.000) ***	
E_t			0.3168 (0.000) ***				0.3687 (0.000) ***	
POP_t				0.1605 (0.066) *				0.0177 (0.043) **
Constant	0.3292 (0.000) ***	0.4159 (0.000) ***	0.3021 (0.000) ***	0.3624 (0.000) ***	0.4163 (0.000) ***	0.6303 (0.000) ***	0.7493 (0.000) ***	0.4482 (0.000) ***
Hansen J-test (p-value)	25.29 (0.39)	28.14 0.304	18.02 (0.604)	14.95 (0.645)	35.44 (0.182)	29.78 (0.371)	24.70 (0.403)	31.84 (0.247)
AR2 test (p-value)	0.251 (0.644)	0.648 (0.601)	0.493 (0.618)	0.217 (0.699)	0.628 (0.694)	0.610 (0.714)	0.478 (0.655)	0.419 (0.714)

Notes: Values in parenthesis are the estimated p-values. The Sargan test refers to the over-identification test for the restrictions in the GMM estimation. The AR (2) test is the Arellano-Bond test for the existence of the second-order autocorrelation in first differences. ***,**and * significant at 1%, 5% and 10% levels respectively

investments and the accumulation of human capital.

Furthermore, the absence of significant relationships between freight transportation (FT) and human capital accumulation (HK) for all examined cases prompts a deeper exploration into the factors influencing the interplay between these variables. This observation raises questions about the specific mechanisms through which transportation and human capital development interact or, in some instances, fail to exhibit discernible connections. Policymakers may need to consider localized factors and conditions influencing the dynamics between transportation infrastructure and human capital investment, tailoring interventions to address region-specific challenges and opportunities. In doing so, a more granular understanding of these relationships can inform targeted policies that promote sustainable economic growth and development in African nations.

The findings of this study unveil a range of robust policy implications that underscore the interconnected nature of factors influencing economic development and foreign direct investment (FDI) in Africa. Firstly, the study emphasizes the pivotal role of transportation networks in enhancing territorial attractiveness and drawing in more investors. The strategic development of modern infrastructures, including ports, airports, railways, and roads, is crucial for facilitating increased FDI inflows and fostering robust economic integration across the continent. Additionally, focusing on the development of maritime transport can substantially impact trade dynamics with European countries, providing further avenues for economic growth.

In parallel, the study highlights the crucial role of human capital development in attracting foreign investments. A well-educated and skilled workforce significantly contributes to the appeal for foreign investors. Policymakers are urged to prioritize investments in education and training programs, not only to attract investors seeking a skilled labor force but also to foster sustainable economic growth through the creation of a knowledge-based economy.

Furthermore, the importance of regulatory frameworks and governance structures in fostering a conducive business environment cannot be overstated. Transparent and efficient regulatory systems, coupled with good governance practices, instill confidence in investors. Policymakers must focus on creating an environment that encourages fair competition, protects property rights, and ensures legal stability. This approach creates an atmosphere conducive to foreign investment and promotes long-term economic development.

Moreover, the study highlights the potential acceleration of the human capital accumulation process in Africa through the influx of FDI. Multinational corporations possess the capacity to enhance the skills and competencies of the local workforce, making it increasingly crucial to the economic development of host countries. Policymakers are urged to invest in local human capital, as a qualified workforce facilitates the diffusion of advanced technologies within the local industrial framework and allows beneficiary countries to assimilate new knowledge from foreign companies.

Additionally, the study underscores the importance of environmental sustainability in attracting foreign investments. Policymakers must consider the ecological implications of economic activities and incorporate environmental sustainability into their regulatory frameworks. This not only

attracts socially responsible investors but also ensures the long-term viability of economic development, aligning with global environmental goals.

In conclusion, a comprehensive and integrated approach addressing transportation infrastructure, human capital development, regulatory frameworks, and environmental sustainability is essential for maximizing the positive impact of FDI on economic growth. Policymakers must consider these multifaceted implications to formulate strategies that promote sustainable development and enhance the overall economic well-being of the region.

Finally, we found that our results could be improved in two ways. First, we can examine the strong relationship between economic growth, transport, and FDI attractiveness and examine their effect on other crucial economic variables such as health expenditure. In fact, we found great motivation to thoroughly examine the short and long-term relationship between economic growth and health expenditure. Second, we can take into account the human development index as an explanatory variable that can considerably ameliorate the quality of the empirical investigations.

However, it is important to acknowledge certain limitations to these improvement perspectives. Firstly, the inherent complexity in analyzing the relationship between economic growth, transportation, and other crucial economic variables, such as health expenditures, may pose methodological challenges. Collecting reliable data and considering various contextual factors will require significant efforts.

Similarly, the integration of the Human Development Index as an explanatory variable may face challenges related to data availability and quality. Discrepancies in data collection among countries can also pose difficulties for a robust comparative analysis.

Regarding the decomposition of freight transport into national and international segments, it is important to note that data specific to this decomposition may be limited. Data gaps could affect the accuracy of results obtained from such an approach.

Furthermore, the in-depth analysis of the relationship between transportation and energy consumption may be hindered by the limited availability of detailed data on transport-specific energy consumption in some African countries.

Lastly, predicting the negative impacts of multinational corporations and recommending more prudent approaches to protect African businesses may be subject to economic and political uncertainties. Complex market dynamics and unexpected changes in the global economic landscape could influence the validity of forecasts and recommendations.

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