IRA-International Journal of Management & Social Sciences
ISSN 2455-2267; Vol.19, Issue 02 (Q.2 2023)
Pg. no. 20-28.
IRA Academico Research

Capital Flows and Technology Transfer between China and Sub-Saharan African Countries

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Type of Work: Peer Reviewed.
DOI: https://dx.doi.org/10.21013/jmss.v19.n2.p1

Review history: Submitted: March 21, 2023; Accepted: June 08, 2023

How to cite this paper:
EKA, F. (2023). Capital Flows and Technology Transfer between China and Sub-Saharan African Countries. *IRA-International Journal of Management & Social Sciences* (ISSN 2455-2267), 19(2), 20-28. DOI: https://dx.doi.org/10.21013/jmss.v19.n2.p1

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ABSTRACT

In the China-Africa trade partnership, foreign direct investment is one of the preferred capital flows of technology transfer, as it incorporates knowledge about the most appropriate technologies. The absorption capacity of African countries is also a fundamental parameter. This article provides an empirical analysis of the factors behind technology transfer between China and sub-Saharan African countries. The analysis covers a sample of nine sub-Saharan African countries, plus China, and covers the period 2003-2021. Using data from the Heritage Foundation (2021), it appears that, on average, countries in sub-Saharan Africa are lagging behind in innovation creation compared to China. The econometric results obtained using panel data analysis show that corruption, technological infrastructure and human capital explain this delay.

Keywords: Capital flows, technology transfer, China, sub-Saharan Africa.

JEL Classification: O30, O57, N70

Introduction

The Capital movements were seriously affected by the war in Ukraine, provoked by Russia, which caused a sharp rise in oil prices. Consequently, many sub-Saharan countries, especially oil and commodity exporters, have had to seek capital to finance increased deficits, thus accumulating debts.

Foreign direct investment (FDI) flows are generally considered the safest[1]. Recent capital outflows and subsequent market instability in some countries such as China show that capital flows are very often volatile and that it is important to improve resilience to possible reversals inflows.

FDI is predominant in Africa. Portfolio investment inflows, in particular debt, securities are not as important in most Sub-Saharan African countries, given the underdeveloped nature of domestic financial markets (domestic stock and bond markets).

Innovation now seems to be seen as the one-size-fits-all solution to all of China's problems. Since then, it has become clear that any further growth and development will now depend on its ability to autonomously create new technologies and build new business models. In short, the "new normal" is a requirement for innovation. China's destiny is linked to its ability to innovate - an ambition that is not without obstacles.

Unlike China, most countries in sub-Saharan Africa have low added value or low technological intensity in the products it exports to China. It should be noted that Chinese scientific publications reach an exceptional number and the number of patents filed is unparalleled. In 2019, China overtook the United States with 58,990 international patent applications filed, compared to 57,840 on the American side[2]. The delay in technological creation of the countries of sub-Saharan Africa compared to China, therefore, seems quite considerable.

President Xi Jinping constantly stresses the crucial importance of China being superior in terms of innovation. Moreover, the idea of better integrating China into international innovation networks, particularly in Africa, has often been mentioned [1]. This objective may motivate certain essential liberalization measures for the protection of intellectual property rights, the management of cross-border data (transferability, local hosting requirements, etc.), the regulation of inward FDI, etc. In any case, within the framework of the new silk roads initiative ("Belt & Road Initiative"),

But beyond these innovation policy instruments, which are still underdeveloped in sub-Saharan Africa, what factors can explain the lag in technological creation in sub-Saharan Africa compared to China?

In this context, this article is structured as follows. Section 2 reviews the literature on capital flows in sub-Saharan Africa and the determinants of innovation gaps between countries. Section 3 describes the data

[1]See, Korinek (2018) and Ghosh, Ostry and Qureshi (2017). The impact of FDI may, however, vary depending on whether it is "new" investment, mergers and acquisitions, or simply a phenomenon of round-tripping flows.

[2]World Intellectual Property Organization, "China Becomes Top Filer of International Patents in 2019 Amid Robust Growth for WIPO's IP Services, Treaties and Finances", April 7,2020,
https://www.wipo.int/pressroom/en/articles/2020/article_0005.html.

and sets out the econometric methodology. Section 4 presents empirical results and finally, we make some concluding remarks.

Review of Litterature

Capital Flows, Technology Transfer and Growth in Sub-Saharan Africa

Some studies have shown that capital flows can stimulate economic growth and development through various channels, in particular, the increase in FDI can facilitate the diffusion of technologies [2,3].

The scientific literature on the role of FDI on endogenous growth highlights two approaches (i) the introduction of new capital goods [4]. This mechanism is based on the principle of a multiplier: the superior technology is first transferred by the multinationals to the subsidiaries and then from the subsidiaries to the local companies, without paying a formal price associated with the transfer. (ii) New technologies transferred to local firms through externalities [5,6].

He assumes that the stock of technology in countrieshost is a function of local capital and foreign capital, but also of the substitution between the two. The presence of FDI opens access to a suite of non-tradable intangible assets, which leads to increasing returns to scale and thus stimulates growth [7].

Some authors, on the contrary, appeal to the private good character of the technology. They use game theory to model the role of FDIs in the transfer technology international. For this, they consider the foreign subsidiary and a company local, both affected by a process of technology accumulation[8].

The multinational transfers the technology to the subsidiary, while the local company absorbs the branch technology. Both the subsidiary and the local company have a response strategy optimal to the actions of the other. Their decisions give the rate of technology transfer. This is all the more intense as the technological lag of the local company is more important and that the cost of imitation of the technology is low. An interesting involvement of the model is the fact that technological externalities force the multinational to constantly renew the transfer to the subsidiary, so as not to lose the advantage technological.

The determinants of the technology transfer gap

Technology transfer (TT) is a process by which an industrial player appropriates a technology from a public player or another private company, most often with a view to marketing it. Such a process involves the transfer of tangible or intangible assets from one entity to another.

Several studies[9, 10,11, 12, 13] have analyzed the factors that explain the development of innovations in a country, or the gap in technological creation between countries. Among these factors, we can cite: the quality of institutions, in particular property rights, taxation, international openness, the nature of competition, access to the financial market, financing of R&D, human capital, etc

The theoretical framework for our analysis draws on the work of [14, 15]. Consider a neoclassical production function of the Cobb-Douglas type:

$$Y_{i,t} = A_{i,t} F_i(L_{i,t};\ K_{i,t}) \qquad (1)$$

L denotes the quantity of the labour factor, K is the quantity of the capital factor and A the technological efficiency or total factor productivity. It is assumed that (i) is homogeneous of degree 1, (ii) the marginal productivities of the factors of production are decreasing, and (iii) the total factor productivity varies according to the country and over time.F_i

Suppose that the technological efficiency of a country is a function of technology transfer (TT) between the leading country (L) and a given country (i).

$$A_{i,t} = g(TT_{i,t}) \qquad (2)$$

Technology Transfer (TT) measures the distance to the technology frontier. It can be represented by a linear equation which is formulated as follows:

$$TT_t^i = inno_t^L - inno_t^i = h\left(X_{j,t}^L - X_{j,t}^i ; P_i\right) = h(Z_{jt}; P_i) \quad (3)$$

X (with j = 1 … … … n) represents the factors likely to influence the distance to the technological frontier. is the country-specific effect and $P_i Z_{jt} = X_{j,t}^L - X_{j,t}^i$.

The calculation of the elasticities of the technology transfer function with respect to the factors indicates the extent to which the technology transfer reacts to variations in the factors.Z_{jt}

Whether $\beta_j = \frac{\partial TT^i}{\partial z_j} * \frac{z_j}{TT^i} \geq 0$ the increase of one point in the quantities of the factor leads to an increase in technology transfer. If, on the other hand, the increase of one point in the quantities of the factor leads to a drop in the technological transfer$Z_{jt}\,\beta_j\,\%\,\beta_j = \frac{\partial TT^i}{\partial z_j} * \frac{z_j}{TT^i} \leq 0 Z_{jt}\,\beta_j\,\%$.

Data Specification

The sample includes eight SSA countries mostly from Central Africa plus China over the period 2003-2020, which is a total of 162 observations. The nine countries are South Africa, Angola, Cameroon, Gabon, Equatorial Guinea, Nigeria, the Central African Republic, the Republic of Congo and China.

To assess the technology transfer index, two indicators were used in the WDI (2021): R&D expenditure and patent counts [16]. R&D expenses are the resources allocated by companies and States in activities aimed at increasing the stock of knowledge of science and technology. They do not provide information on the output of these activities in terms of innovations. The number of patents, on the other hand, is a possible indicator of innovation activities. This indicator is obtained from 2 variables: the number of patents granted per 1 million people and of articles in scientific and technical journals.

The level of technological infrastructure will be measured through the technological infrastructure index contained in the WDI database (2021). This index is calculated from four indicators: the number of fixed broadband Internet subscriptions per 100 inhabitants, the number of fixed-line telephones per 100 inhabitants, the number of cellular mobile subscriptions per 100 inhabitants and energy consumption. electricity (kWh per inhabitant).

To measure human capital, we will use the human skills index available in the WDI database (2021). This index is calculated on the basis of 3 indicators: the literacy rate among people aged 15 and over, the number of enrollments in higher education per 100,000 inhabitants and the average duration of schooling for adults.

In the economic literature, several indices make it possible to measure the degree of international openness of a country's economy. In this study, we will choose the Heritage Foundation's free trade index which measures the absence of tariff and non-tariff barriers affecting exports and imports of goods and services.

We measure the reduction of corruption in government on a scale of 0 to 6. The lower the score, the higher the corruption and vice versa, according to the ICRG database.

The Heritage Foundation Financial Freedom Index (2021) was used to jointly represent financial liberalization and financial development. This index captures the efficiency of banks and the withdrawal of the State from the financial sector.

To measure the "reduction of the tax burden", Heritage Foundation (2021) constructed the fiscal freedom index which considers the degree of absence of the tax burden imposed by the public authorities. It considers three indicators: the marginal tax rate on individual income, the marginal tax rate on corporate income and the total tax burden as a percentage of GDP.

To capture “business freedom”, we will use the freedom affairs index constructed by Heritage Foundation (2021). This index is a possible measure of the effectiveness of government business

regulation. It is built from 10 indicators. The business freedom score for each country is a number between 0 and 100%. When it is equal to 100%, the business climate is said to be free.
The property rights index is constructed from the following indicators: the degree of protection of private property rights by the laws of a country, the level of application of these laws by the government, the likelihood that private property expropriated, the independence of the judiciary, the existence of corruption in the judicial system, and the ability of individuals and businesses to enforce contracts. It is provided by the Heritage Foundation database (2021).

Table 1 – Definition and data sources of model variables

Abbreviation	Variable	Source
$caphuman$	Human capital	World Development Indicators
$infra$	Technological infrastructure	World Development Indicators
$ttech$	Technology transfer	World Development Indicators
$fiscalite$	Tax pressure	Heritage Foundation
$corruption$	Corruption	International Country Risk Guide
$trade$	Free exchange	Heritage Foundation
$finance$	Financial liberalization	Heritage Foundation
$entrepreneuriat$	Competition	Heritage Foundation
$dpropriete$	Property rights	Heritage Foundation

Source: Author's calculation

Econometric Methodology

Several factors motivate Chinese investments in sub-Saharan Africa, in particular, positioning near innovation centers with a view to inserting themselves upstream in the value chains.
In accordance with the econometric model developed by [17], we want to determine the variables that explain the evolution of the gaps in technology transfer between China and the countries of sub-Saharan Africa. More precisely, this relation is written:

$$(ttech_{chine,t} - ttech_{i,t}) = \alpha_0 + \alpha_1(infra_{chine,t} - infra_{i,t}) + \alpha_2(caphuman_{chine,t} - caphuman_{i,t}) + \alpha_3(trade_{chine,t} - trade_{i,t}) + \alpha_4(corruption_{chine,t} - corruption_{i,t}) + \alpha_5(fiscalite_{chine,t} - fiscalite_{i,t}) + \alpha_6(finance_{chine,t} - finance_{i,t}) + \alpha_7(dpropriete_{chine,t} - dpropriete_{i,t}) + \alpha_8(entrepreneuriat_{chine,t} - entrepreneuriat_{i,t})$$

i represents the African countries of our study sample and t captures the years of observations of the model variables (t = 2003, 2004, … … ……, 2020).

Results and Analysis

Table 2 shows that the innovation gap between China and Sub-Saharan Africa is significantly and positively correlated respectively with their gaps in technological infrastructure, human capital, reduction of corruption, protection of rights ownership, and competition. However, the gap in terms of innovation between China and sub-Saharan Africa is significantly and negatively correlated with their gaps in terms of development, access to the financial market, and lower fiscal pressure. In addition, the low correlation between most of the explanatory variables suggests an absence of multicollinearity between the different explanatory variables.

Table 2 –Correlation coefficients between model variables

	Ttech	infra	cap human	trade	corruption	taxation	Finance	Property	entrepreneurship
ttech	1,000								
Infra	0.211**	1,000							
cap human	0.611**	0.476**	1,000						
Trade	0.258**	0.289**	0.66**	1,000					
corruption	-0.39**	0.095	-0.32**	-0.08	1,000				
taxation	0.575**	0.467**	0.39**	0.100	-0.029	1,000			
finance	0.690**	0.6**	0.68**	0.37**	-0.253**	0.717**	1,000		
property	-0.19**	0.16	0.037	0.152	0.078	0.032	0.146	1,000	
entrepreneurship	0.071	0.47**	0.3**	0.334**	-0.280**	0.071	0.322**	0.138	1,000

Source: Author, estimates made from Stata 19 (** significance at 5%)

Stationarity and cointegration tests were not applied in this study since the size of the panel is smaller (9 countries) and the study period is not long enough (18 years). However, an analysis of the linear links between the explanatory variables, but also with the explained variable, can make it possible to highlight that the explanatory variables do not present strong linear relationships between them. For this, we will proceed to the analysis of the Variance Inflation Factor (VIF). Table 5 shows an absence of multicollinearity between the explanatory variables of the model.

According to Table 3, we observe that the p-values associated with the various statistics F1, F2 and F3 described above are well above the significance level of 5%. Thus, the panel model without individual effects is well suited to the data available to us for the econometric estimation of our model.

Due to the positive value of their coefficients, sub-Saharan African countries must make considerable efforts in terms of "human capital", "technological infrastructure" and "fight against corruption" to reduce their lag behind China in terms of technological innovation.

The “human capital” variable displays a positive coefficient and is not significant; which may explain the lag in innovation that sub-Saharan Africa lags behind China. Moreover, we note its non-significance. The estimation of the coefficients capturing the specific country effects shows that, with the exception of South Africa, the rest of the countries considered have not begun the process of catching up in terms of the creation of innovations vis-à-vis China.

This result suggests that innovation policies in these countries do not seem to occupy a place of choice in the process of economic development. Most of the time, in these countries, innovation policies often have difficulty being applied and suffer from a lack of coherence. This is not the case for China, which gives priority in terms of innovation in order to catch up with its technological backwardness in comparison with other world powers [18].

Table 3 –Estimation of the pooled model

	Model without heteroscedasticity correction		**Robustness model (heteroscedasticity correction)**	
Variable	**Coefficient**	**Standard deviation**	**Coefficient**	**Standard deviation**
Infra	0.069	0.0119	0.069	0.064***
Caphuman	0.033	0.0118**	0.033	0.0086**
Trade	-0.0241	0.0026***	-0.0241	0.0119*
Corruption	0.0272	0.0093***	0.0272	0.0088***
Taxation	0.0237	0.0090***	0.0237	0.0087***
Finance	-0.0239	0.0139***	-0.0239	0.0067***
Property	-0.0871	0.0081	-0.0871	0.0083
Entrepreneurship	0.0273	0.0173***	0.0273	0.0173***
Constant	-0.0097	0.0015***	-0.0097	0.0027***
prob>*F*= 0.000****F*(8; 136) = 34.94			*prob*>*F*= 0.000****F*(8; 136) = 38.69	

Table 4 –LSDV model without heteroscedasticity correction

	Model 1[3]		**Model 2**[4]		**Model 3**[5]		**Model 4**[6]	
Variables	**Coefficient**	**Standard deviation**	**Coefficient**	**Standard deviation**	**Coefficient**	**Standard deviation**	**Coefficient**	**Standard deviation**
Infra	0.1570***	0.0223	0.174***	0.028	0.172***	0.028	0.174***	0.027
cap human	0.0331	0.0231	0.029	0.041	0.029			
Trade	-0.029****	0.0093	-0.037***	0.015	-0.05***	0.013	-0.037***	0.015
corruption	0.0141**	0.0071	0.015	0.013			0.021**	0.013
taxation	-0.0393***	0.0079	-0.047***	0.014	-0.050***	0.013	-0.045***	0.014
finance	-0.0206***	0.0056	-0.026***	0.011	-0.026***	0.011	-0.029	0.011
property	-0.0159	0.008			-0.016	0.013	-0.019	0.014
Entrepreneurship	-0.0371***	0.0105	-0.042***	0.016	-0.047***	0.016	-0.041***	0.016
South Africa	-0.0104***	0.0045	-0.015**	0.01	-0.015**	0.01	-0.019***	0.01
Angola	-0.0181***	0.006	-0.02***	0.012	-0.024***	0.012	-0.018***	0.01
Cameroon	-0.0119***	0.0048	-0.018***	0.011	-0.015**	0.011	-0.0118***	0.011
Guinea Eq.	-0.0101**	0.0048	-0.013*	0.01	-0.016**	0.01	-0.01***	0.009
Nigeria	-0.0263***	0.0052	-0.032***	0.011	-0.032***	0.011	-0.03***	0.011
RCA	0.0011	0.0035	0.0023	0.009	0.008	0.009	0.0012	0.009
Republic of Congo	-0.0102***	0.0031	-0.024***	0.009	-0.018***	0.009	-0.025***	0.009
Constant	-0.0094**	0.004	-0.014**	0.01	-0.018***	0.01	-0.013	0.009
	prob>*F*= 0.000*** *F*(16; 136) =52.38		*prob*>*F*= 0.000*** *F*(15; 136) =54.36		*prob*>*F*= 0.000*** *F*(15; 136) =54.23		*prob*>*F*= 0.000*** *F*(15; 136) =55.39	

[3]Model that integrates all the explanatory variables,
[4]Model without the property right variable,
[5]Model without the corruption variable,
[6]Model without the human capital variable.

Source: Author, estimates made from stata 19 (***, **, * respectively represent the significance at 1%, 5% and 10%).

Corruption is a key element that explains the delay of sub-Saharan African countries over China in terms of technological creation. Compared to China, the Corruption Perceptions Index is higher in some Sub-Saharan African countries. For example, Cameroon and Nigeria have often been ranked "the most corrupt country in the world" for several years by Doing Business. Corruption in sub-Saharan Africa is manifested by red tape that can compromise the creation of businesses and innovation projects.

China has placed emphasis on the construction of technological and telecommunications infrastructures (internet access, development of the telephone network, etc.). This is not the case for several African countries which still suffer from a shortage of electrical energy supply and a lack of technological infrastructure.

Indeed, most African countries have an extremely low rate of access to ICT services, compared to other countries in the world. According to the NRI (Networked Readiness Index)2021, Sub-Saharan African countries rank last due to relatively low private sector investment in telecommunications infrastructure (lowest rates of internet penetration, internet usage, use of computers and telephone subscription in the world).

Conclusion and Recommendations

FDI is the main capital flow that serves as a tool for technology transfer from China to African countries. This article has proposed an empirical evaluation of the explanatory factors of the gap in technology transfer between China and the countries of sub-Saharan Africa. To achieve this objective, the approach adopted was carried out in three stages.

In the first step, we relied on the scientific literature to model the determinants of the gap in technology transfer between China and the countries of sub-Saharan Africa. In the second step, a formal framework, making it possible to model the explanatory factors of the gap in terms of technology transfer between China and the countries of sub-Saharan Africa, was developed. In the third step, the estimation of the model in panel data showed the increase in the gap in terms of (i) the fight against corruption, (ii) the construction of technological infrastructures and (iii) the development of human capital between China and the countries of sub-Saharan Africa, explains the lag of these countries in terms of innovation in comparison with China. And so,

Our results could be improved if they are not faced with the following difficulties: (i) the nature of technological innovations and their indicators (patents, etc.) only correspond to a fraction of the innovations made; others are done in less formal ways; (ii) the explanatory factors and their indicators also have limits, with a choice certainly dictated by the economic literature, but very much oriented on the legal and economic conditions (financing, protection, etc.), and less on other institutional aspects, demographic or economic (the nature of the firms, etc.); (iii) the lack of statistical data which guided the choice of the sample of sub-Saharan African countries retained.

The recommendations in terms of economic policies that can be addressed to the leading countries of sub-Saharan African countries are: (i) to adopt effective strategies in the fight against corruption, which often prove to be ineffective; (ii) to develop technological infrastructures. In Cameroon, the digital infrastructure has developed considerably over the past decade, despite this progress, the unreliability of internet connectivity is still a significant obstacle. African leaders must increase public investment in technological infrastructure; the latter must rely on models that can be inexpensive, and in close contact with networks of entrepreneurs and students, etc.; (iii) define financial support policies that are more credit-oriented; and (iv) increase investments in the development of human capital, but without doubt by favouring the training of engineers and technicians.

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