Acta Sci. Pol., Administratio Locorum 23(1) 2024, 19–29.
https://czasopisma.uwm.edu.pl/index.php/aspal plISSN 1644-0749 eISSN 2450-0771 DOI: 10.31648/aspal.9135

ORIGINAL PAPER
Received: 29.06.2023 Accepted: 11.11.2023

WHAT DRIVES CHINESE TECHNOLOGY IMPORTS INTO AFRICA? A REGIONAL PERSPECTIVE

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ABSTRACT

Motives: The factors that affect technology imports from China have never been examined in the literature, and this study was undertaken to fill in this knowledge gap. The factors that drive high-tech imports from China to Africa, including those that negatively impact imports, were identified. The results can be used to implement changes in the trade strategies of African countries, including industry 4.0 strategies or trade agreements with China, and to influence the behavior of companies importing high-tech from China.
Aim: The primary goal is to identify the factors that influence technology transfer, in particular the transfer of electronic and electrical technologies, in the areas of high-tech manufacturing. The second goal is to determine whether these factors have equal strength and direction of influence on different streams of technology transfer.
Results: The study demonstrated that both economic and geographical factors influence technology transfer, defined as two streams of high-tech manufactures: electronic and electrical, as well as other high-tech manufactures. However, the two import streams behaved differently, and different factors affected Chinese imports into Africa.

Keywords: Africa, China, technology transfer, technology imports

INTRODUCTION

In research on the relationship between China and Africa, technology imports as a form of technology transfer is a relatively unexplored topic (Oqubay & Lin, 2019). There are two conflicting views in the discourse. Some authors argue that Africa's openness to trade with China has not resulted in technology transfer to African countries (Elu & Price, 2010; Patroba, 2012; Youngman, 2013). Others point to the positive impact of importing capital goods from China to Africa, as technology transfer occurs simultaneously (Kaplinsky & Morris, 2009; He, 2013; Munemo, 2013). Various internal or external factors influencing the possibility of technology transfer have been identified by authors (Borojo & Jiang, 2016), but research has often failed to determine what factors influence the transfer of technology from China to Africa.

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It is reasonable to explore the area of Chinese-African cooperation in foreign trade, particularly the import of high technology from China, as it is a key channel for technology transfer. This is especially important since China introduced the Digital Silk Road as part of the Belt and Road Initiative in 2016, aimed at promoting and transferring Chinese technologies abroad. The study has two primary objectives: to investigate the economic and geographical determinants that impact technology transfer in the form of high technology manufactures, and to verify if these determinants affect different streams of technology transfer equally. The secondary objective is to check if technology transfer can be expressed using the aggregates used in the study. High-tech goods were divided into two categories: electronic and electrical high technology manufactures, and other high technology manufactures. This was done intentionally as they are different groups. China is the global leader in exporting electronic and electrical high technology manufactures, but has a small share in exporting other high technology manufactures.

The subject of the study is 53 African economies grouped into 5 regions according to the criterion of geographical location following "Geographic Regions" from United Nations Statistics Division (United Nations Statistics Division, 2022). To investigate the determinants of the Chinese imports with the use of the trade gravity in levels approach in a panel data set covering the period 2016–2021, we have applied the semi-mixed effect method using the Poisson pseudo-maximum likelihood (PPML) estimator as suggested by the recent empirical literature.

The article is divided into three parts: an introduction, a main section, and a conclusion. The first part reviews the literature and justifies the research issues. The second part describes the data and methods used. The third part presents the results and discusses them. The conclusion refers to the research questions, the purpose of the analysis, and its limitations.

LITERATURE REVIEW AND JUSTIFICATION OF THE TOPIC

There aren't many extensive studies that examine the trade connections between China and African countries and how it affects Africa's development, especially in terms of technology (Eisenman, 2012; Obobisa et al., 2021). Using the two-step GMM estimator system (Borojo & Jiang, 2016) analyzed the impact of trade relations between China and Africa on the total factor productivity (TFP). A study was carried out between 1995 and 2013, covering 38 countries. The results indicated that trade openness between Africa and other countries had a significant positive effect on the GDP growth of African nations. Furthermore, when trade openness between Africa and China was combined with improvements in institutional quality and human capital in Africa, the impact on TFP became positive and significant. The authors of the study concluded that for technological progress to result from trade with China, it is necessary for Africa to have a strong domestic absorptive capacity.

An extensive study on the links between China's trade with sub-Saharan Africa and technology transfer was conducted by Elu and Price (2010). An analysis of micro-level data from manufacturing firms in five sub-Saharan African countries was conducted, estimating firm-level production function parameters from 1992 to 2004. The results showed that increasing trade openness with China did not have an effect on the growth rate of TFP. This led to the conclusion that, in the long term, trade with China cannot be considered a source of prosperity for the countries analyzed. According to Munemo (2013), importing capital goods from China can significantly enhance technology transfer and stimulate economic growth in Africa. Therefore, it is essential to implement trade liberalization policies that attract Chinese capital investment.

He (2013) used regression analysis to evaluate the impact of imports from China on the exports of goods from Sub-Saharan Africa, in comparison to imports from the United States and France. The results showed that China's influence was

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significantly positive and stronger than that of the US and France. Furthermore, it was demonstrated that Chinese imports have a positive effect on the economic development of Sub-Saharan Africa, including technology spillovers, particularly those from moderately advanced technologies.

Hou et al. (2021) conducted a study focused solely on Ghana, using panel data at the company and industry level. They found that the effect of international trade on the productivity of Ghanaian manufacturing firms depends on the competitive advantage of the industry and trading partners. The empirical results showed that trade with China provides more opportunities for firms to increase productivity compared to trade with OECD countries. A higher intensity of imports from China was found to stimulate productivity growth.

Patroba (2012) and Youngman (2013) also studied specific African countries (Kenya and Botswana, respectively). Patroba (2012) found that Kenya imports both high-value-added and low-quality counterfeit products from China, while exporting unfinished goods. This trade pattern does not result in technology transfer. Youngman (2013) obtained similar results in his considerations.

To build the most precise representation of how trade with China affects technology transfer to Africa, several criteria were employed. The emphasis was on articles from the past ten years, and their citation on popular websites such as Mendeley or Semantic Scholar was a key factor in their selection. The literature review was divided into two parts. The first set of papers examined the use of gravity models in China-Africa trade relations, comparing the variables and approaches used by the authors. The second set of papers examined the impact of foreign trade on technological progress and technology transfer in Africa, with panel data analysis being an important selection criterion. These papers helped to identify additional variables that influence technological progress in the countries studied.

Numerous studies have demonstrated the influence of technology on international trade. A few examples are provided below.

Turkson et al. (2020) conducted a large-scale study that analyzed bilateral trade flows in Sub-Saharan Africa, with a focus on ICT. Their research, which covered 29 countries from 2004–2014, showed that prioritizing ICT development significantly increases trade. Additionally, Shinyekwa et al. (2019) examined the impact of COMESA on industrialization and productivity. Their analysis of the period from 2001–2015 confirmed the group's positive impact on industrialization, but the share of TFP was lower than expected, indicating a lack of convergence with international knowledge spillovers.

Some studies have focused on specific technologies, such as the one by Billon and Rodriguez-Crespo (2020) which examined the impact of the Internet, mobile phone, and broadband usage on bilateral trade flows in 33 sub-Saharan countries from 2004 to 2014. A gravity model was used to assess the combined effect of ICT usage and trade facilitation on intra-trade flows. The results showed positive and significant effects for mobile phone ownership in the exporting country, a positive impact of broadband on both exporters and importers, and a positive impact of internet usage on the importing country. However, trade facilitation had a negative effect on bilateral trade and there was an inverse relationship between ICT usage and trade facilitation, suggesting that a lack of trade facilitation may hinder the potential benefits of ICT usage in intra-sub-Saharan African trade.

Currently, there are a limited number of articles that discuss the impact of foreign trade on technological progress, including those mentioned in the introduction by Borojo and Jiang (2016), Elu and Price (2010), Munemo (2013), Patroba (2012) and Youngman (2013). However, the conclusions drawn from these studies are not clear-cut and only a select number of countries were included in the research.

The most direct connection between trade and technology transfer is through the direct import of advanced products, which is a method of technology transfer through trade that is often overlooked (Eaton & Kortum, 1999). In the article, the import of advanced machines and equipment, or high-tech goods, is considered as a main channel for transferring

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embodied technology. This is alongside acquiring intellectual property rights such as technical know-how, patent and license agreements, and human capital migration as vehicles for transferring uncodified knowledge. Given the low level of innovation in the surveyed countries, the focus was on the most obvious channel for technology flow – embodied in high-tech goods – as other channels are less important to the continent. As a result, the article identifies technology transfer to Africa with this type of import, acknowledging the simplification used. High-tech goods imported by African countries are not homogeneous, so the study separately included electrical and electronic products and another category. The analysis may enhance scientific understanding of the role of various factors influencing imports of high technologies from China to African countries. There are only a few studies in the literature cited above that show the impact of trade with China on technological progress in Africa.

None of the studies have attempted to answer the question of what factors affect the import of technology from China. Additionally, no study has included all African countries, divided into 5 geographical groups, in relation to their trade relationship with China in high technology. Such a comprehensive analysis has not yet been conducted, and it could deepen our understanding of trade relations between Africa and China in high-tech goods. This analysis could also suggest changes in the foreign policy of African economies towards trade with China and the role of FDI related to the import of high technologies (Ankapo & Oyenubi, 2022; Młynarski, 2012; Wysiński, 2020).

The study has practical implications as it identifies factors that affect high-tech imports from China to Africa, including those that negatively impact imports. This information can be used to make changes in the trade strategies of African countries, such as modifying government industry 4.0 strategies or trade agreements with China, and changing the behavior of companies importing high-tech from China (Krukowska, 2022; Żukowski, 2020).

MATERIALS AND METHOD

This research utilizes multiple data sources to gather information on trade between African countries and certain macroeconomic indicators. The first source is UNCTAD, which provides data on foreign trade (including high technology products), GDP, FORCE, and OUTPUT. The second source is the World Bank, which provides data on RES. The final source is a website with a calculator used to calculate the distance between the capitals of countries (https://www.distancecalculator.net/).

The study investigates almost all African countries that trade with China and for which data is available. The countries have been divided into 5 groups/regions (Northern Africa NA, Western Africa WA, Central Africa CA, Eastern Africa EA, and Southern Africa SA) according to "Geographic Regions". A total of 53 countries were included in the study (two countries, Saint Helena, and Sudan, were excluded from the analysis due to lack of data). The analysis period covers annual data from 2016–2021. Detailed descriptions of the economic potential of individual African regions and the business climate can be found in Cieślik (2022) and Szukalski (2013).

Intensity exchange in the field digital technology from China to countries Africa is measured by two alternative dependent variables: flow of high technology manufactures electronic and electronic (MTCE) as well as flow of other high technology manufactures (MTCO).

The variable MTCE stands for flow of high technology manufactures: electronic and electrical from China to African country. This category includes the most popular electrical and electronic office devices machines, automatic data processing machines or telecommunication equipment. These products are China's flagship exports to world markets, especially developing countries (Cieślik et al., 2020; UNCTAD, 2023). The variable MTCO stands for flow of high technology manufactures: other, which include more specialized technological products, such as aircraft, pharmaceuticals, or more complex specialized equipment. This type of products is much less frequently

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produced in China, which is also reflected in the incomparably lower export values of these products. Although China has specialized in high technology manufactures: electronic and electrical, it is no longer a major high technology manufacturer in the world manufactures: other. The exact division of the main categories into subcategories is presented in UNCTAD (2023). Moreover, African countries are not yet technologically advanced enough to import more high-tech categories manufactures: other. At the moment, there is a much greater demand for typical high technology manufactures: electronic and electrical.

The basic explanatory variables include the size of partner as measured by the log of Gross Domestic Product (log GDP) and the log of the distance between trade partners (log DIST). The distance was measured as the distance between the capitals of trade partners from African countries and China. These are classic variables used in a gravity trade model. To control the effect of capital labour and capital productivity, we use the following variables: total employment in all activities in thousand (in USD millions) and output per capita (in USD). We also included the ratio of natural resources to GDP of African countries (RES) as an indicator: Total natural resources rents (% of GDP) (World Bank, 2022).

African countries differ in the level of wealth, and this may affect the level of trade with China. In connection with the above, it was assumed that the greater the differences in the level of development of countries measured by GDP, the lower the intensity of trade between these countries. As a measure of the development gap, the difference between GDP per capita for individual pairs of countries was determined according to the formula:

$$rfl_{ijt} = ln\left|GDPpc_{jt} - GDPpc_{it}\right| \quad (1)$$

We furthermore apply a number of dummy variables identifying the country belonging to a given geographical group, so we have 5 dummy variables (for $i = 1, 2, 3, 4$ or 5).

A gravity trade model can be treated as one of the most important tools in the trade analysis. It enables to determine and predict actual trade flows. The model has been known for 60 years – it was first presented in 1962 by Jan Tinbergen. Over time, the model has been developed quite intensively and currently has many empirical specifications/modifications.

With the increase in research, mainly empirical, using a gravity model, there have been many considerations regarding the correctness of the selection of its estimation method depending on the form of its specification, both due to its analytical form and variable inclusion in the model. The basic assumption adopted in the model is that trade flows from and to country are proportional to the GDP of both countries and inversely proportional to the distance between the countries (Tinbergen, 1962). Due to its natural limitations, this assumption seems to be insufficient, which is one of the reasons why additional variables representing the specific features of both partner countries have been included in the model (Westerlund & Wilhelmsson, 2009).

The stochastic version of the panel data gravity equation has the following form:

$$T_{ijt} = \alpha_0 Y_{it}^{\beta_1} Y_{jt}^{\beta_2} Z_{ij}^{\gamma} X_{ijt}^{\alpha} e^{\delta D_{ij} + \nu_t + \eta_{ij}} \varepsilon_{ijt} \quad (2)$$

where ν_t are time effects which could account for business cycles, η_{ij} are unobserved heterogeneity effects, and ε_{it} is the stochastic error term. Further, $\alpha_0, \beta_1, \beta_2, \gamma, \alpha, \delta$ are unknown coefficients. It is worth noting that within the panel data it is possible to include unobserved individual effects (i) and time effects (t) as well as effects for pairs of countries (i, j), and at the same time, all of them can be treated as constant or random.

In the classic approach, the model (2) is transformed into a log-linear form and then estimated using OLS. In the case of this estimation method, it is necessary to fulfill the assumption of independence of the explanatory variables of the model and the random component (homoscedasticity). Failure to meet this assumption results in the OLS estimation being inconsistent and biased (Santos Silva & Tenreyro, 2006). The proposed extension of the initial model to the form of additional explanatory variables may potentially generate a risk of heteroscedasticity.

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The second problem with logarithmic transformations is the occurrence of zero or very low trade flows and, consequently, impossibility to calculate the logarithm value and perform the transformations mentioned[1].

As a solution to both of the above estimation problems (OLS mismatch and null flows), Santos Silva and Tenreyro (2006) proposed the Poisson pseudo-maximum-likelihood (PPML) estimator, which is often used for counting data. According to classical economic theory, if two variables are related by a constant elasticity model, as is the case with a gravity model, the function can be interpreted as a conditional expectation of the value of the explanatory variable for a given level of the explanatory variable. Obtaining an effective parameter estimate is possible in this case by using the PPML estimator. The authors argue that for this estimator, the data need not be Poisson distributed and the response variable need not be an integer for the Poisson likelihood-based estimator to be consistent. Moreover, the use of the estimator eliminates the problem of zero flows (Westerlund & Wilhelmsson, 2009).

The estimating regression of gravity model using PPML method has the following form:

$$T_{ijt} = exp\begin{bmatrix} ln\alpha_0 + \beta_1 lnY_{it} + \beta_1 lnY_{jt} + \gamma lnZ_{ij} \\ + \alpha lnX_{ijt} + \delta D_{ij} + \nu_t + \eta_{ij} \end{bmatrix} \varepsilon_{ijt} \tag{3}$$

where: Tijt is the trade flows from country i to country j, Yit, Yjt are GDPs of the two countries' i and j, Dij is the distance between the countries, Zij denotes time-invariant information, *Xijt* denotes time-variant information, *νt* are time effects which could account for business cycles, *ηij* are unobserved heterogeneity effects, and εit is the stochastic error term. Further, *α*0, *β*1, *β*2, *γ*, *α*, *δ* are unknown coefficients. It is worth noting that within the panel data it is possible to include unobserved individual effects (*i*) and time effects (*t*) as well as effects for pairs of countries (*i*, *j*), and at the same time, all of them can be treated as constant or random (Anderson & Van Wincoop, 2003).

It should be noted that in regression (3) the time effects, ν_t and the country-pair-specific effects η_{ij} are estimated as fixed effects, which means that some time-invariant effects cannot be estimated. In accordance with the above discussion, the estimation of all gravity models presented in the article was carried out using the PPML procedure with robust standard errors in Stata 16.

RESULTS

The analysis is carried out for 53 trade partners of African countries and China in the period 2016–2021. The summary statistics of the variables used in the analysis are shown in Table 1.

The average MTCE was about 327513 (thousands USD) in the sample. The average MTCE level in the sample was 327513 (thousands of USD) with a very large deviation of 828549 (thousands of USD), respectively. The average MTCO was 38567 (thousands of USD) and the standard deviation of the sample was 85523 (thousands of USD). Both the deviation values and the difference between the minimum and maximum MTCE and MTCE values indicate a large diversification of high technology flows/imports from China to individual African countries. Such differentiation is also observed in the case of other variables describing the volume of exports and imports from both China (ALIC and ALEC)

70% of the countries surveyed have access to the sea (SEA), and distance from China (DIST) is the relatively least dispersed variable, as shortest distance to China is 7542 km from Egypt and the longest is 12640 km from Cabo Verde.

[1] There are several methods in the literature for addressing the issue of zero flows. One approach is to simply exclude country pairs with no turnover from the data, but this can result in the loss of information and unreliable estimation results. Another option is to use the original trade flow series between countries as the dependent variable, but this can lead to a wide range of values and attempts to rescale the series often result in inaccurate estimates. A further solution is to use nonlinear least squares (Frankel & Wei, 1993), which is an asymptotically correct estimator for a nonlinear flow model, but may be inefficient due to its failure to address heteroscedasticity (Santos Silva & Tenreyro 2006).

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Table 1. Summary statistics for variables for the sample of African countries in 2016–2021

Variable name	N	Mean	SD	Min	Max
MTCE	318	327513	838549	292	7937232
MTCO	318	38567	85523	8	926044
ALIC	318	1795552	3372563	6653	25988152
ALEC	308	1223137	3417460	8	29830576
GDP	317	44584	85355	348	474517
FORCE	318	13168	19094	66	114017
PROD	317	4119	4374	212	23658
DIST	318	10640	1464	7542	12640
RES	318	9	8	0	47

The average GDP for the countries in the sample was 44584 units, with a deviation of 85355 units. In the case of the FORCE variable, it was on average 13168 units with a deviation of 19094 units, and for the PROD variable, the average was 4119 units with a deviation of 4374. We also observe a large variation in the RES variable, for which the mean is 9% and the deviation is 8%. The range of values for the natural resources of African countries ranges from 0% for Mauritius and South Sudan to 47% for Congo.

The estimation of the basic and extended specifications of the empirical model has been performed using a PPML with robust standard errors and with a dummy variable for group membership serving as a clustering variable. For the reasons indicated earlier, it was not possible to include the Sea variable in the model. The analysis was conducted for 53 of China's African trading partners in 2016–2021. Two explanatory variables were used in the study, i.e. the value of imports from China (y1), MTCE in (thousands of USD) and MTCO (thousands of USD).

Various model specifications were tested and shown in the table * 10 models. The overall matching of the models is high, explaining 85% to 95% of the variability of imports depending on the specification. The results are robust to potential modifications.

In most of the analyzed comparisons, the coefficients of traditional gravity model variables, such as the GDP of an African country and the distance between China and a given African country, are economically justified and their impact on the dependent variable is statistically significant. The intensity of Chinese imports decreases with the distance to the trading partner in the case of the MTCO variable for all groups, and increases in the case of the MTCE variable. As expected, it was shown that geographical proximity is an important determinant of trade flows (imports) in the case of the MTCO variable, and this fact, in the classical approach, may be associated with lower transport and information costs. In the case of the second variable, we have a situation contradicting our expectations, which may suggest focusing on determining the costs of transport and information related to the import of MTCE. According to the theory of Baldwin and Harrigan (2007), as the quality of products increases, so do their costs and profitability, making it more advantageous for China to enter more distant markets with its high-tech products due to higher profitability. In other words, the most efficient companies, such as Chinese high-tech firms, export high-quality products to the furthest markets. Melitz (2003) also examined markets in a similar manner, arguing that firms exporting to more distant markets should be more productive and therefore able to offer lower prices than those only exporting to nearby markets.

The impact of the wealth of an African country measured by GDP is as expected, and it is positively statistically significant only for countries of group 2 EA and 5 WA in the case of the variable MTCE of imports from China, while in the case of models of the MTCO variable, the relationship is opposite to the expected one: the higher the level of GDP, the lower the import of MTCO from China to the country,

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regardless of group affiliation. This phenomenon can be explained by the fact that other economies (the most developed), and not China, specialize in the MTCO category. Countries that reach a certain level of wealth (expressed, for example, by GDP) decide to purchase high tech manufactures: other products from other economies that specialize in their production. On the other hand, the low level of wealth of the average African country forces it to buy high tech products: other from China (they cannot afford a better manufacturer), although China does not specialize in them and probably offers goods of lower quality.

The impact of the development gap shown by rfl is negative (but not significant) for the MTCO variable, suggesting that the difference in development between an African country and China is irrelevant to the volume of MTCO imports. In the case of the MTCE variable, the value of the coefficient is statistically significant and positive, which suggests that the greater the difference in development between a given African country and China, the greater the tendency to import MTCE from China.

As in the case of GDP, the country's raw material wealth turned out to be significant only in the model of the MTCE variable for two groups of countries: 3 CA and 5 WA, and its negative value indicates that the greater the country's resource wealth in relation to GDP, the lower the import of MTCE from China to these countries. CA and WA are characterized by strong raw material ties with China, hence only for these regions the variable is significant. On the other hand, the negative relationship can be explained by the fact that these countries, strongly basing their economy on raw materials, are not interested in importing modern technologies. Chinese companies located in these regions are also focused on raw materials and do not import high-tech to their plants.

The impact of the labor force of an African country measured by FORCE is negative and statistically significant only for the countries of the 2 EA and 5 WA groups[2] for the MTCE variable of imports from China, while for the models of the MTCO variable, the relationship is positive and significant for all groups, which shows that the higher the FORCE level, the higher the import of MTCO from China into the country. On the other hand, the positive relationship between FORCE and MTCO can be explained by the specificity of this product category.

The impact of the African country's productivity measured by PROD is negative and statistically significant for all African countries for the MTCE variable of imports from China, which means that the higher the PROD, the significantly lower the MTCE imports from China. However, in the case of models of the MTCO variable, the relationship is positive and significant for all groups, which means that the higher the PROD level, the higher the import of MTCO from China to the country. An increase in productivity may mean a decrease in demand for further Chinese high-tech products of electrical and electronic equipment, which may indicate that the market has already been saturated with these products. On the other hand, in the case of MTCO, which is much lower compared to MTCE, there may still be potential in the market to increase imports and/or the process of increasing the level of efficiency/productivity may stimulate the demand for MTCO.

The influence of belonging to a given geographical region is clearly statistically significant in the case of the MTCE variable. African countries from groups 1 NA and 5 WA import significantly less than other countries, and of course, similarly, countries from groups 2 EA, 3 CA and 4 SA import significantly more MTCE from China than other countries. In the case of the MTCO variable, it should be noted that only the countries of group 4 SA import significantly more MTCO from China than other countries, while the countries of group 2 EA import significantly less MTCO from China than other ones.

[2] These two regions are characterized by the largest workforce in Africa, labor-intensive production, and at the same time are heavily dependent on Chinese exports of high – tech electrical and electronic equipment (UNCTAD, 2023).

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Table 2. Results of model estimation for MTCE (1–5) and MTCO (6–10)

Regressor	MTCE					MTCO				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
lnDist	0.407*	1.113*	0.987*	0.145	1.283*	-0.782	-1.408*	-1.205*	-1.529*	-1.321*
lnGDP	3.043	10.483*	3.428	4.218	11.431**	-57.041*	-67.253*	-57.725*	-57.722*	-58.897*
lnFORCE	-1.937	-9.354*	-2.322	-3.158	-10.313**	58.046*	68.228*	58.733*	58.716*	59.892*
lnPROD	-10.289*	-17.088*	-10.064**	-9.848*	-16.697*	58.910*	68.601*	59.165*	59.807*	60.113*
RES	-0.502	-0.548	-0.861*	-0.376	-0.922*	-1.208	-1.354	-1.039	-0.782	-0.886
rlf	7.818*	7.271*	7.220*	6.148*	5.911*	-1.081	-0.678	-0.632	-1.274	-0.424
Group 1	-0.275*	-	-	-	-	0.225	-	-	-	-
Group 2	-	0.295*	-	-	-	-	-0.401*	-	-	-
Group 3	-	-	0.034	-	-	-	-	0.049	-	-
Group 4	-	-	-	0.505*	-	-	-	-	0.269*	-
Group 5	-	-	-	-	-0.424*	-	-	-	-	0.103
Constant	59.255*	98.917*	51.958	58.094*	94.256*	-414.031*	-474.366*	-411.649*	-413.373*	-416.897*
R2	0.945	0.945	0.938	0.951	0.951	0.846	0.850	0.846	0.849	0.842

*p<0.05; **p<0.10

CONCLUSIONS

The study found that both economic and geographical factors influenced technology transfer, understood as two streams of high technology manufactures: electronic and electrical, and other high technology manufactures. The determinant coefficients in most of the estimated models, such as the GDP of an African country and the distance between China and a given African country, were statistically significant, confirming the basic assumption of a gravity trade model and the importance of geographical distance in trade flows (imports). The impact of an African country's wealth, measured by both GDP and the level of the development gap (rlf), was somewhat in line with expectations. The model estimation results showed that the greater the difference in development between a given African country and China, the greater the tendency to import MTCE from China. Other determinants affecting the volume of imports from China included labor force and productivity per capita.

Then the article verified whether the determinants included in the study affected two different streams of technology transfer with equal strength and in the same direction. The study showed that determinants with different strengths and directions affected technology transfer streams. Different results were obtained for importing high technology manufactures: electronic and electrical and high technology manufactures: other. In the case of the first category, the streams were very high and reacted to changes in determinants differently than the stream of the second category with significantly lower values.

On the other hand, the objective of the study was to investigate whether technology transfer could be expressed using aggregates applied in the study. Both at the descriptive level and model estimation, we observed different shapes of distribution for both variables and different reactions to changes in determinant values, consistent with the second objective. These differences became even greater after analyses taking into account the geographical division of African regions.

At the end of considerations, several research limitations and areas for further research should be mentioned.

A major obstacle was limited availability of statistical data for African countries. Therefore, two economies were excluded from study, and for remaining

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ones, variables included in study had to be reduced to those that were reasonably complete. It is possible that access to more detailed data would identify additional factors influencing high-tech imports from China to Africa.

Moreover, the study relied on specific methods, and it cannot be excluded that other methods would have led to different conclusions. However, the method used seemed to the authors to be most appropriate for this type of study.

Furthermore, this study should be repeated in subsequent years to confirm results, especially due to the war in Ukraine. This event may likely have disrupted earlier trends.

Worth noticing, the study was conducted at a certain level of detail – high-tech goods were divided into two categories. However, within each category, there are more specific types of products. It is possible that a more detailed analysis would more accurately identify determinants affecting the import of specific technology from China.

Additionally, the study divided Africa into regions geographically, but it is possible that using a different division of economies could result in different study outcomes.

It's worth adding at the end, that the analysis could be expanded to include other economies, such as European or Asian countries, to compare their position in African technology imports with China. Such a comparison could lead to adjustments of ineffective strategies or the introduction of innovative tools in African countries.

Author contributions: The authors have approved the final version of the article. The authors have contributed to this work as follows: Ewa Cieślik and Anna Zamojska developed the concept and designed the study, Ewa Cieślik collected the data, Anna Zamojska analyzed and interpreted the data, Anna Zamojska estimated and interpreted the models, Ewa Cieślik drafted the article, Ewa Cieślik revised the article critically for important intellectual content.

Funding: This research was undertaken as part of the "Digital Silk Road as a network of technological connections between China and Europe within value chains: towards win-win or decoupling?" project and was fully funded by the National Science Centre, Poland (UMO-2021/43/B/HS4/01079).

Supplementary information: The authors would like to thank the Reviewers for support in preparing the article.

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