Investigating the Impact of Chinese Financing on Productivity in the African Continent

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Abstract

Given that productivity is a key component of long-term economic growth and that China has become an important source of external financing in Africa, this study aims to investigate the impact of Chinese foreign direct investment and government-to-government loans on productivity. Using a panel of the top fourteen African recipients of Chinese financing during the period 2003-2017, this study employs a two-stage regression process. The first relies on the use of a revised version of the Solow Model that accounts for human capital, natural resource accumulation and country-specific heterogeneity, to generate values of total factor productivity. The second examines the impact of Chinese financing on this generated measure of productivity. After taking into account significant confounding variables such as institutional quality, trade openness and manufacturing value-added, this study finds that Chinese foreign direct investment (FDI) has a significant negative impact on productivity while Chinese government loans are positively associated with productivity. However, consistent with the literature, the impact of Chinese FDI depends on the country's absorptive capacity – proxied here by the level of human capital accumulation. Therefore, as African countries seek to boost productivity levels, they should continue to attract Chinese government loans while enhancing their FDI absorptive capacity.

JEL Classification: C23; F21; O47; O55

Keywords: China; Africa; Foreign Direct Investment, Government Loans, Productivity

I. Introduction

A. Productivity Challenges in Africa

Productivity is often recognized as one of the main underlying contributors to long-term economic growth. Coupled with sound distributional and development policies, productivity can facilitate poverty alleviation and contribute to the improvement of living standards (Tamirat & Mahlakgane, 2017). Highly productive businesses are able to more efficiently utilize physical capital, reduce production cost and generate higher profit. Moreover, productivity gains in an industry can increase the number of employment opportunities while increasing average earnings (Hornbeck & Moretti, 2018). While the benefits of productivity are widely acknowledged, African countries exhibit low levels of productivity for several reasons.

Firstly, the African economy, excluding extractive economies such as the DRC, is largely agrarian based. Low productivity within this industry due to small farm sizes, low-skilled workforce, and lack of farm machinery partly explains overall low productivity on the continent (Wood, 2016). Secondly, low levels of human capital caused by weak public education and health infrastructure and high unemployment rates limit productivity growth. Individuals who lack sufficient education and training are unable to contribute to the innovation and efficiency required for productivity growth. Thirdly, the shortage in capital, both domestic and foreign, prevents investment in technological innovation that is essential to spurring productivity growth. This suggests that businesses that seek to boost productivity often lack the capital required to invest in more efficient production processes. Lastly, the size of the informal sector is a deterrent to productivity growth. In Africa, 85.8% of employment is in the informal sector (*Women and men in the informal economy*, 2018). The informal economy is associated with low productivity as it employs less productive workers and permits the existence of firms that cannot thrive within the

formal market (Palmer, 2008). For these reasons, Africa faces significant productivity challenges that need to be curbed in order to sustain long-term economic growth.

External financing can fuel a country's productivity in four major ways. Firstly, it provides capital to emerging economies where domestic capital and savings are scarce. ThE additional capital from China is used to support critical sectors of the economy such as transport infrastructure (Marais & Labuschagne, 2019). Secondly, the influx of external financing into a country allows for the exchange of crucial skills and technology that increase productivity. This is especially true in the case of China since a majority of the loans are carried out through contracted projects. The exchange of skills and technology further creates a favorable environment for diversification and exploration of new markets. In sectors such as manufacturing where African countries are lagging behind in productivity levels, Chinese financing has significant positive impacts (Yuan Sun, Jayaram, Kassiri, 2017). Thirdly, this larger and more efficient allocation of capital is typically complemented with the opening of businesses that create jobs for locals. This allows formerly unemployed individuals to gain productive employment. Therefore, it is clear that external capital has the potential to contribute to productivity growth that is indispensable to long-term economic growth. Given the growing influence of China in Africa, this study evaluates whether this claim holds for Chinese financing in Africa.

B. Sino-African Relations

Over the past few decades, China has increasingly become an important external financier for the African continent. The sight of Chinese construction companies and Chinese workers has become an everyday phenomenon in most African countries. Between 2007 and 2017, China's top leadership (the president, the premier or the foreign minister) made a total of 79 visits to 43 African countries to cement their diplomatic and commercial relationship (Dahir, 2018). China's vested

interest in the continent seems to be reciprocated by African leaders who are increasingly looking towards China to fulfill their financing needs. A strongly suggestive example is the attendance of 51 African leaders at the Forum on China–Africa Cooperation in Beijing as compared to a mere 27 at the United Nations General Assembly in New York in 2018. While this doesn't say much about the nature of Sino-African relations, it is a telling example of the growing interconnectedness between the two.

China's financial engagement in Africa is driven by its triple-pronged long-term economic strategy (Brautigam, 2011). Following China's rapid economic growth in the 1990s and early 2000's, the surge in demand for natural resources forced the Chinese government to establish commercial relationships with African countries. Secondly, China's growing manufacturing sector needed an outlet for its cheap goods. The African continent, which lacked a strong manufacturing sector, provided a suitable market for Chinese companies seeking to avoid the saturated market in their country. Lastly, China sought to develop its political reputation as a rising but responsible power. Under the "Going Global" strategy, China sought to send Chinese multinational companies overseas and make them more competitive (Naidu & Mbazima, 2008). However, they emphasized that this outward expansion would be accompanied by mutually beneficial economic opportunities.

However, this approach of the Chinese government has been criticized for three main reasons (Zhao, 2014). Firstly, China's non-interference policy allows it to support the violation of human rights and prop up authoritarian regimes. For instance, China continued to be Sudan's largest importer of oil during the Darfur genocide while continuing to arm government forces. Secondly, China is blamed for resource extraction and for exploiting African countries' need of finance to fuel its economic growth. While this system of resource-backed loans is not new, the Chinese government systematized and scaled it to a great extent. Lastly, China is criticized for

insensitive labor practices. Instead of hiring local workers, Chinese companies recruit Chinese professionals and laborers alike. For instance, in 2009 in Angola, 70-80% of employees in Chinese companies were Chinese. Even when they do hire local employees, Chinese companies are infamous for unfair labor laws and practices. Thus, while Chinese financing has enormous potential on the continent and can provide all the benefits discussed above, these negative implications need to be taken into consideration.

C. Components of Research Question

This study aims to answer the question: "How does Chinese financing affect productivity on the African continent?" There are three important aspects of this question that we need to further break down. Firstly, we need to define what Chinese involvement is in the context of Africa. Chinese involvement in Africa can be categorized into two types – foreign direct investment and government loans. In this study, Chinese financing is disaggregated by funding source in order to tease out the different impacts on productivity. This will add to the growing literature evaluating Chinese involvement in Africa by providing strong evidence on the different sources of investments.

Secondly, we need to define a measure of productivity. As we will discuss in the literature review and in the theoretical framework section, most papers examining productivity at the macro-level utilize the Solow Residual as a measure of total factor productivity. In accordance with the economic literature, this study will use the Cobb-Douglas production function to estimate output production and consequently obtain values of productivity for each country, during each time period. However, unlike the Solow model which only captures physical capital and human labor, this study will incorporate a measure for human capital and raw materials. Given the countries that

this study is exploring and the resource-heavy intentions of China, including a measure of raw materials in the production function is critical.

The last consideration in this question is the number of countries this study will focus on. Given that we only have data on Chinese investment in Africa from 2003-2017, we won't have enough data points to run a statistically significant regression using just one country. Therefore, the more obvious option would be to study several African countries using country fixed effects to control for differing characteristics between states. This would give us more data points to analyze.

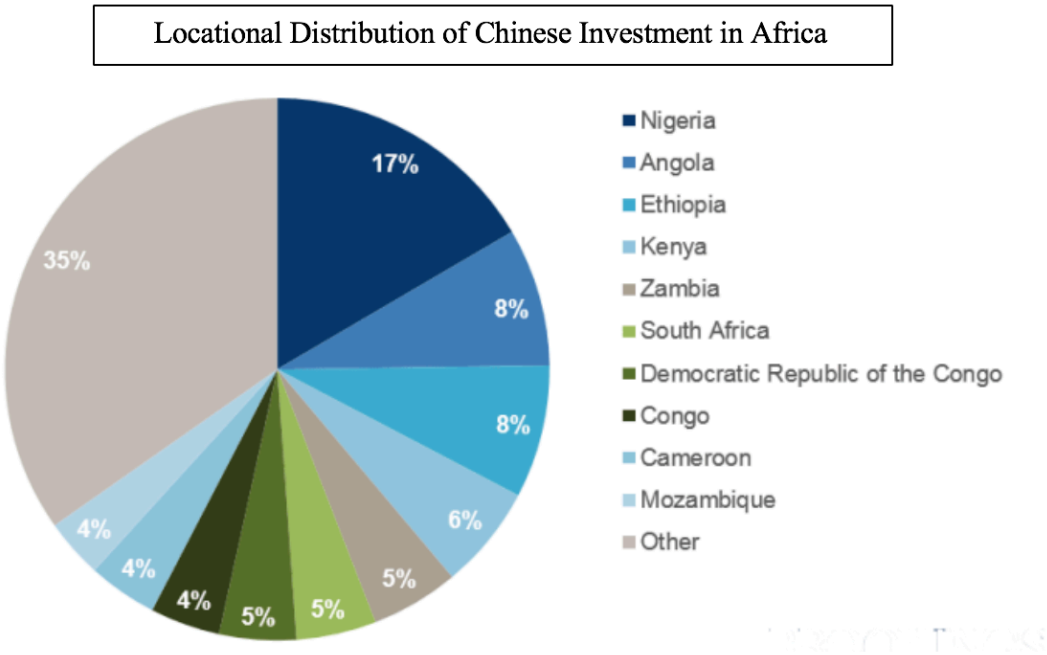


Figure 1: Brookings, Chinese Investment Tracker (AEI)

Figure 1 shows the top 10 recipients of Chinese financing[1]. In order to maximize the likelihood of seeing the impact of Chinese financing on productivity, focusing on countries that

[1] Note that the Chinese Investment Tracker from the American Enterprises Institute aggregates FDI data and loan data. This explains why Nigeria is the largest recipient of Chinese financing in this pie chart. We will see below that South Africa is the largest recipient of FDI.

receive the most investment makes the most sense. In addition to these countries shown above, I have also included the next top 4 recipients – Ghana, Mauritius, Algeria, Sudan – in order to increase the number of observations while ensuring that I have a complete data series for all my variables of interest. As one scrolls down the list of China's financing recipients, the data for the control variables become less complete. Thus, looking at these 14 countries – Nigeria, Angola, Ethiopia, Kenya, Zambia, South Africa, DRC, Republic of Congo, Cameroon, Algeria, Mozambique, Ghana, Mauritius and Sudan – will allow me to increase the number of data points and reach the threshold necessary to make statistically significant conclusions without compromising the quality of my dataset.

II. Background on Sources of Chinese Financing

China's financial engagement with the African continent can be categorized into two distinct sources – foreign direct investment (FDI) and government loans.

A. Foreign Direct Investment

Foreign direct investment (FDI) is often considered a means for developing countries to boost their economic growth, diversify their economies and maximize human resource potential. According to the Chinese Ministry of Commerce, FDI is defined as:

> "an activity in which an investor resident in one country obtains a lasting interest in, and a significant influence on the management of an entity resident in another country. This may involve either creating an entirely new enterprise (so-called "greenfield" investment) or, more typically, changing the ownership of existing enterprises (via mergers and acquisitions – brownfield investment). Other types of financial transactions between related enterprises, like reinvesting the earnings of the FDI

enterprise or other capital transfers, are also defined as foreign direct investment. (Brautigam, 2018)"

FDI serves as an external source of funding for governments and private companies, providing the physical and sometimes the human capital necessary to initiate new projects and sustain or expand existing ones. In addition, FDI enhances the efficiency of existing markets by allowing for the exchange of technological innovations and best practices. As such, developing countries consider FDI to be a central element of their economic development strategy and a more sustainable alternative to foreign aid flows which can be subject to political whims. Therefore, countries in Africa are attempting to create more favorable economic environments to encourage multinational companies and governments to invest in their countries.

Foreign direct investment into Sub-Saharan Africa has exhibited promising trends over the past few decades. The average share of FDI relative to total inflows increased from 24% in the 1990s to 75% during the 2000s, with Nigeria and South Africa, the continent's two largest economies, accounting for 50% of this foreign investment (Chuhan-Pole, 2013). Within the 27-year period between 1990 and 2017, while the global inward flows of FDI increased by almost 8.8 times, FDI inflows into Africa increased by a factor of 14 times (Marandu, 2018). Between 1996 and 2000, the extractive sector received 55% of FDI inflows, followed by the service sector which received 25% and the manufacturing industry which received 20%. In the past decade, this has been reversed with the service, manufacturing and extractive sectors receiving 55%, 29% and 16% of FDI inflows respectively. The countries that provide the most foreign direct investment are the United States, the United Kingdom, France and China.

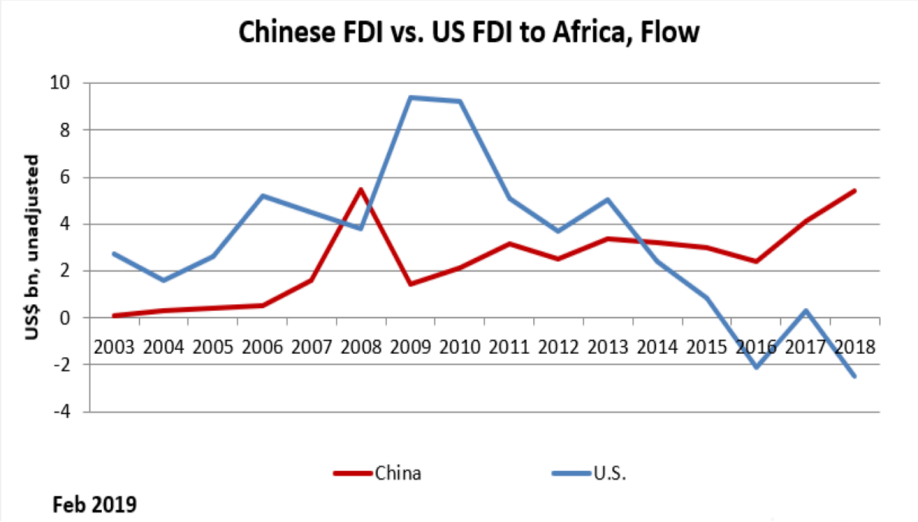


Figure 2: Sourced from SAIS-CARI

Over the past few decades, China has become an increasingly important investor in Sub-Saharan Africa, overtaking the US since 2014. Figure 2 above shows that, between 2003 and 2014, Chinese FDI increased significantly from $491million to $3.2billion, reaching its height in 2008 and stabilizing over the 2011-2014 period (Gandhi, 2018). Over the same period, the number of Chinese FDI recipients increased as the stock of FDI directed to each country was spread more evenly. Nevertheless, Chinese FDI is till concentrated in six resource-rich countries – South Africa, Nigeria, Zambia, Algeria, Democratic Republic of Congo, and Sudan – and most of the FDI is directed towards mining, construction and finance sectors (Donou-Adonsou, 2018).

B. Government Loans

While FDI is an important source of Chinese financing, it is by no means comparable to the amount of government loans provided to African governments. The three new policy banks formed in the 1900s – China Development Bank, China Export Import Bank, and China Agricultural Development Bank – served as tools of government finance, providing loans to African governments and seed capital to Chinese companies operating on the African continent.

Guided by their motto of economic cooperation for mutual benefit, China sought to develop strong relations with African governments. They provided concessional loans during a period when Western countries were cutting back on loans to African governments. China adopted a non-interference policy in state affairs, presenting itself as a strong alternative to Western powers that attached political and structural contingencies to their loans (Naidu & Mbazima, 2008). During the annual Forum on China-Africa Cooperation in 2018, President Xi further emphasized China's commitment to its non-interference policy (Copley, 2018). In addition to these concessional loans, China commits to servicing construction and transportation projects in exchange for natural resources. For countries lacking the monetary capability to pay back loans, this infrastructure-for-resources agreement has been a lucrative deal (Alves, 2013).

During the period 2000 to 2017, the Chinese government, banks and contractors provided 143billion US dollars to African governments and contractors. Figure 3 below shows that this has been upward trending in the past two decades but has been declining since 2013 with a sudden jump in 2016. This is explained by China's increased loans to Angola which made it China's third largest oil supplier.

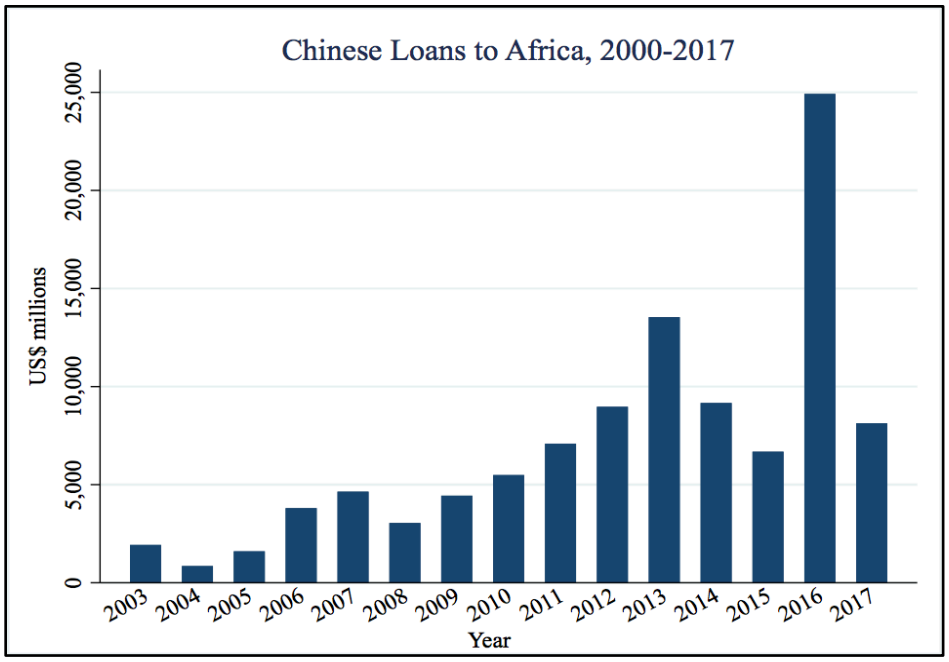


Figure 3: Sourced from SAIS China-Africa Research Initiative

The major channel of Chinese government loans is through contracted projects backed up by natural resources. When a Chinese bank such as the Export-Import bank signs a contract with an African government to finance a construction project, Chinese companies are in charge of the operation. The money that the Export-Import bank lent to the government is either paid over-time or immediately, in the form of natural resources. It is important to note that the requirement to employ a Chinese construction company to service the project makes Chinese financing logistically different from other sources of external financing. This condition can allow for important technological spillovers and human capital accumulation that contribute to productivity growth, much like the impact we expect from foreign direct investment.

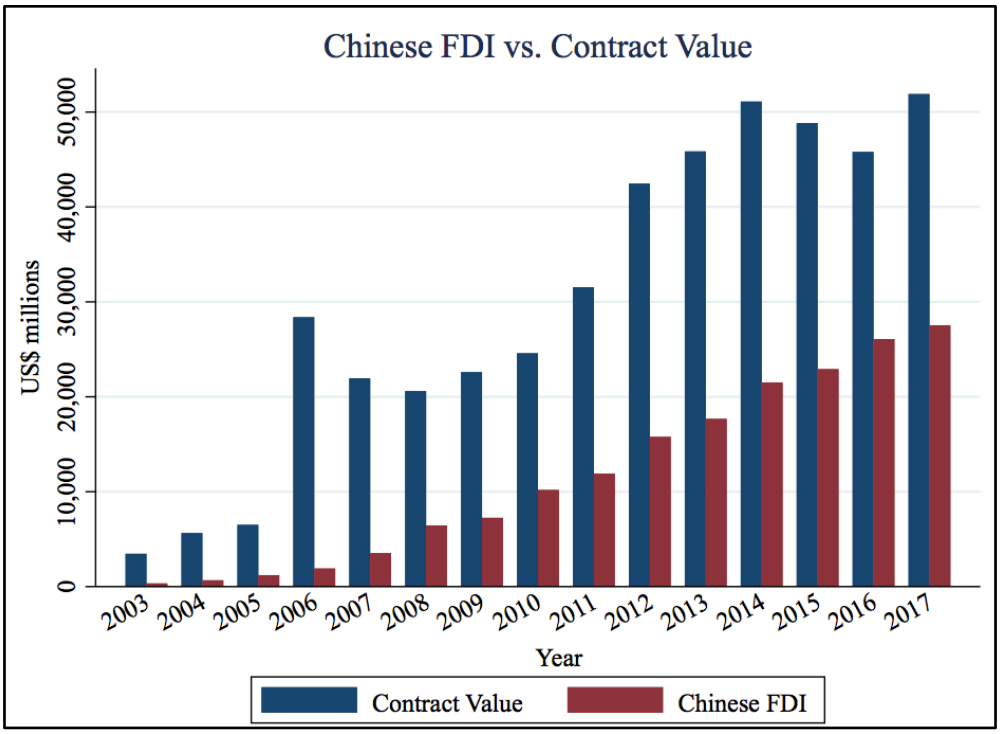


Figure 4: Data sourced from CARI

While data exists on both total loans as well as the value of contracted projects, there is a significant overlap between the two. Moreover, the data on the value of contracted projects is a more complete series than the data on total loans. As a result, this paper will be looking at contract value as a proxy for government loans. According to the Ministry of Commerce, contracted projects "refer to activities of contracting overseas construction projects by Chinese enterprises" and constitutes a large portion of Chinese loans to African governments (Brautigam, 2018). Figure 4 above further emphasizes the magnitude of government loans, as proxied by contracted projects, compared to Chinese FDI. In 2015, the value of contracted projects was more than 2 times the amount of FDI funneled into Africa. This suggests that loans are a more important source of financing for the African continent.

III. Literature Review

A. Pull Factors of Chinese Financing

It is important to start off with an understanding of the pull factors that drive Chinese investment in Africa. This will frame our understanding of the sectors in which Chinese investment can have the most impact as well as the mechanisms through which these impacts manifest. Cheung, Haan, Qian and Yu, (2012) empirically demonstrate that the market and resource seeking motives significantly explain China's investment in African countries. However, they also show that a host country's natural resources affect not just the decision to invest but also how much to invest. This explains why China invests throughout the continent but largely focuses on resource-rich economies such as Nigeria. Sanfilippo (2010) furthers this argument by showing the importance of China's market-seeking intention (to offload its low-cost goods) and resource-seeking intention (to fuel its demand of natural resources) in its decision to invest in Africa.

However, Cheung et al. (2012) add that Chinese investors have an ambiguous approach to risk factors, investing in politically unstable countries in certain cases and avoiding them in others. In fact, a study by Chen, Dollar and Tang (2018) supports this phenomenon of indiscriminate investing, showing that China's overall FDI is uncorrelated with a measure of rule of law. Lastly, Cheung et al., (2012) show that China's "Go-Global" policy contributes to its decision to invest in African countries. While not directly answering my research question, these studies exploring the pull factors of Chinese involvement frame the context of Chinese financing activities in the African continent. Understanding this context will be invaluable in choosing the control variables as well as examining the mechanisms through which Chinese investment could affect productivity.

B. FDI and Growth

Most empirical studies focus on developing the link between investment and overall economic growth. For instance, Borensztein, De Gregorio and Lee (1995) utilized a cross-country regression framework to analyze the impact of FDI flows from industrial countries to 69 developing countries in the period between 1975 and 1995. They find that for each percentage point increase in the FDI to GDP ratio, economic growth increases by 0.8 percentage points. However, this impact is highly dependent on the country's level of human capital – those with higher levels of human capital benefit significantly more from FDI inflows than countries with lower levels. Building on Borensztein et. al. (1995)'s research, Dinh, Vo, The Vo, and Nguyen (2019) show that FDI stimulates long-term economic growth in developing and emerging markets. However, in the short-run, FDI has a detrimental effect as domestic firms share the market with foreign firms. In support of Borensztein et. al., (1995)'s paper, they show that human capital accumulation is central to ensuring economic growth. However, Dinh et. al., (2019) warn that the effectiveness of FDI depends on the type, sector, duration and scope of the FDI.

Similarly, Iamsiraroj & Ulubaşoğlu (2015) explore the relationship between FDI and economic growth investigating 108 studies spanning 140 countries during the period between 1970 and 2009 and generate 880 estimates. They also find a strong positive relationship between FDI inflows and growth. However, unlike the Borensztein et. al. (1995) paper, the authors find that trade openness and financial openness are more fundamental "absorptive capacity indicators" rather than human capital accumulation. Alfaro, Chanda, Kalemli-Ozcan and Sayek (2006) argue that financial markets allow the linkage between foreign and domestic firms to turn into spillovers. They show that an increase in the share of FDI has a higher positive impact on growth in financially developed countries than in financially poor economies. There are two main take-away points from

this research. Firstly, while researchers disagree on the mechanism through which FDI inflows affect economic growth, it is taken as fact that foreign direct investment spurs growth. Secondly, institutional capacity – whether trade openness or the quality of the public sector – is a key determinant of the extent of the impact of FDI on economic growth.

C. Chinese Investment and African Economic Performance

The literature exploring the impact of Chinese investment on African economic performance is limited to conjectures and analytical frameworks that provide potential explanations. This is largely due to the difficulty of compiling reliable Chinese investment data as well as the shortage of available data due to the relatively new phenomenon of Chinese involvement in Africa. Among the few studies done on this topic, Donou-Adonsou and Lim's (2018) paper rigorously explores the impact on African economic performance. Their study utilizes the fixed effects and instrumental variable approach over a panel of 36 African countries during the period between 2003 and 2018. After controlling for human capital, trade openness, local investment, financial development and regulatory quality, they establish that Chinese FDI positively contributes to standard of living, measured as income per capita. This study stands out from other papers as it disaggregates total FDI into its components, allowing the authors to compare the impact of Chinese FDI to US and German FDI. They find that overtime, Chinese FDI is crowding out US FDI, making my research significantly timely and relevant.

Similarly, Doku, Akuma, and Owusu-Afriyie (2017) use least squares regression and a fixed effects model to quantify the effect of Chinese FDI on economic growth. They find that a 1% increase in FDI stock increases GDP growth by 0.607% holding all else constant. While this study focuses more specifically on total factor productivity, Doku's (2017) paper provides useful insights into the mechanisms through which FDI affects macroeconomic performance and a clear

explanation of relevant control variables. Furthermore, Donou-Adonsou and Lim's (2018) study provides an adaptable methodology since this study aims to disaggregate total FDI inflows into FDI from China and total FDI from other countries. In addition, Chinese financing will be broken down into FDI and value of government contracts.

D. FDI and Productivity

A study by Malikane and Chitambara (2017) more generally explores the link between FDI and productivity. The authors investigate the impact of FDI on total factor productivity in a panel of 45 countries over the period between 1980-2012. By implementing a fixed effects model and a two-step Generalized Method of Moments (GMM) method, they establish that FDI has a generally weak but positive effect on productivity growth. Similarly, Li & Tanna (2019) examine the relationship between FDI and productivity using cross-sectional data on 51 developing economies over the period 1984-2010. Much like Malikane and Chitambara (2017), they also find a weak but positive effect of FDI on TFP growth. However, when accounting for human capital and quality of institutions, Li & Tanna (2019) find "robust FDI-induced productivity growth". This result supports the claim that absorptive capacity is crucial to determining the extent to which FDI contributes to productivity growth. This study will thus be including measures of human capital and quality of institutions to account for this absorptive capacity.

Arisoy (2012), using data from Turkey over the period 1960-2005, breaks it down further and shows that in the long-run FDI contributes to TFP growth through capital accumulation and technological spillovers. He used the aggregate production function to deduce measures of productivity growth. Furthermore, he uses the Granger causality test to establish a causal relationship between FDI and productivity growth. This study provides solid reasoning for our expectations of the impact of Chinese FDI on productivity. Interestingly, Malikane and

Chitambara's (2017) findings do not support convergence theory which argues that "relative backwardness would lead to higher productivity growth via the adoption of foreign technology". Given that there are conflicting arguments regarding the convergence theory, it is important for my research to evaluate the role of relative backwardness in facilitating the transfer of foreign technology. In this study, the share of manufacturing value-added as a percentage of GDP represents a country's level of development.

When examining the impact of FDI on productivity growth, it is crucial to be aware of other critical variables that influence TFP growth. Several studies have explored factors that contribute to productivity in Sub-Saharan Africa. Fadiran and Akanbi (2017) use a panel of 26 Sub-Saharan African countries during the period 1990-2011 and employ the Fully-Modified Ordinary Least Squares (FMOLS) estimation technique to account for endogeneity of regressors. They find that there is a consistent relationship between institutions and productivity, showing that including a measure of institutions significantly reduced the explanatory power of other variables. Interestingly, they also establish that the importance of market-based institutions is stronger than political ones. This study will thus include variables that measure both political and market-based institutions.

Similarly, Loko and Diof (2009) using the GMM dynamic panel estimator on data from the Maghreb region, also establish that strong institutions – described by the degree of regulation of credit, labor and business, rule of law, and the economic freedom index – are key to ensuring productivity growth. Loko and Diof (2009) provide two other significant insights. Firstly, they demonstrate that FDI has a significant positive impact on TFP growth, especially when the country has high levels of human capital. Countries with a highly skilled domestic workforce are better able to take advantage of the knowledge spillover that comes with foreign investment. Secondly,

they establish that trade openness, human capital and macroeconomic stability are significant contributors to TFP growth. These two papers together establish a comprehensive list of the determinants of productivity growth that I need to control for when evaluating the impact of FDI on TFP.

This paper contributes to the existing literature in a couple of ways. Firstly, while most papers examine the impact of Chinese investment on growth, this study looks at its impact on productivity. As will be outlined later in the theoretical framework section, productivity growth is the major contributor to long-run economic growth. Therefore, this study will allow us to take one step back and examine the impact of Chinese investment on productivity growth, an engine for economic growth. Secondly, this study breaks up this outward investment into private and public sources to examine if difference in funding source matters. This allows us to make claims about the most successful ways to boost African productivity. Lastly, this study will be comparing the impact of Chinese investment to total investment from other countries to determine if there is anything significantly different about Chinese investment. This study will thus contribute to the ongoing debate about the nature of Chinese investment on the African continent by providing data-backed claims tested through rigorous econometric techniques.

IV. Theoretical Framework

The study of economics has developed several models to explain the macroeconomic performance of countries throughout the past century. These models often take into consideration the level of physical capital and human labor in a country as well as some measure of technology, among other factors. An examination of the theoretical framework surrounding the impact of Chinese financing on productivity will thus utilize such a model to establish an empirical relationship between Chinese financing and productivity. The most well-known of these is the Solow growth model. The Solow model is a neo-classical production function that attempts to explain long-run economic growth as a factor of population growth, capital stock and technological progress. It is often used as the empirical tool to understand cross-country growth patterns. While the Solow model was derived in the 1950s, it still remains a popular tool in macroeconomics for several reasons. Firstly, it provides a simplistic model that helps us understand the determinants of a country's long-run output production. Secondly, it provides an explanation for varying growth rates between countries, providing levels of capital stock and population growth rate as explanatory factors. Lastly, given the difficulty of quantifying technical efficiency, the Solow growth model provides a reasonable approach to accomplish this task. For these reasons, the Solow growth model lends itself as an appropriate model for this study.

However, the Solow model has certain limitations that we need to be aware of. Firstly, technological efficiency is taken as exogenous. Therefore, the model fails to explain its origin, or ways in which countries could advance their level of productivity. Secondly, it does not provide a theory of sustained long-term growth. According to the model, in its simplest form, countries eventually converge to a steady state of growth when capital accumulation equals depreciation, leaving no room for continuous growth. While we need to acknowledge the limitations of this

model, it adequately answers the question in this study. In addition, most of the research papers cited in the literature review exploring the impact of FDI on productivity have used the Solow model to indirectly deduce values of productivity, giving my approach more legitimacy.

The Solow growth model assumes that both labor and capital have diminishing returns (Agénor, 2004). The more capital or labor an economy employs, the marginal value of that input decreases. Due to this diminishing marginal returns, the Solow model concludes that the only mechanisms through which countries can sustain long-run economic growth are by ensuring consistent technological progress, labor productivity growth, or population growth. In order to ensure technological progress and labor productivity growth, countries need to invest in research and development and in creating production processes that increase efficiency. With this, comes the need for investment, both domestic and foreign. While an exogenous increase in investment can increase growth through a buildup of capital stock, it must result in the creation or the transfer of technological prowess to sustain long-run economic growth. Under this framework, external financing inflows increase the per capita stock available and consequently increase the per capita growth rate. FDI plays a role in technology transfer and allows for more efficient production processes that counteract the diminishing marginal returns of capital. As mentioned above, foreign direct investment positively affects productivity by allowing for the transfer of new technological processes in the form of "new goods, new markets and new processes" (Knell, 2000). While there could be certain factors such as "market-reallocation effect"[2], "linkage-disruption effect"[3], and "skill-stealing effect"[4] that counteract the positive impacts of foreign investment, this is not the focus of this study (Liu, 2016). However, it is important to keep them in mind.

[2] Market reallocation effect is the action of foreign firms taking demand from local firms.
[3] Linkage-disruption effects is the disruption of the network that exists between local businesses.
[4] Skill-stealing effect is the movement of skilled workers from local to foreign firms.

This technological growth that Solow demonstrated is crucial to long-term growth is referred to as total factor productivity (TFP) and is equated with the Solow residual. Once we account for growth in the economy that is explained by growth in the input factors, any excess growth is captured by TFP. This theoretical framework on total factor productivity provides the necessary background for my measure of technological productivity.

The most commonly used specification of this function is the Cobb-Douglas production function:

$$Y = A K^{\alpha} L^{1-\alpha} \tag{1}$$

Where: $0 < \alpha < 1$

The Cobb-Douglas production function satisfies the properties of a neoclassical production function (Brown, 2017). The marginal products of labor and capital are positive, suggesting that a larger labor or capital input leads to the production of more output. Moreover, it has constant returns to scale of both capital and labor and displays diminishing marginal returns. In addition, the marginal products indicate that capital and labor are complements in the production function. These assumptions can explicitly be written as mathematical statements.

Positive marginal products of capital and labor:

$$f'(K) = \alpha K^{\alpha-1} L^{1-\alpha} > 0 \text{ and } f'(L) = \alpha K^{\alpha} L^{-\alpha} > 0$$

$$\lim_{K \to 0} f'(K) = \infty \text{ and } \lim_{L \to 0} f'(L) = \infty$$

Diminishing marginal returns to capital and labor:

$$f''(K) = \alpha(\alpha - 1) K^{\alpha-2} L^{1-\alpha} < 0 \text{ and } f''(L) = \alpha(-a) K^{\alpha} L^{-\alpha-1} < 0$$

$$\lim_{K \to \infty} f'(K) = 0 \text{ and } \lim_{L \to \infty} f'(L) = 0$$

In this function, Y represents output, A represent multifactor productivity or technological progress, K is physical capital and L is a measure of the population engaged in productive activity. Usually, labor is measured by the average number of hours worked. However, this data is not

available for most of the countries in my dataset. Therefore, we will use the number of people working as a substitute for number of hours worked.

This residual approach has been criticized heavily since it inherently captures omitted variables, measurement error and model misspecification error in addition to technical efficiency – the component of growth we are interested in (Hulten, 2000). In order to minimize this error, we will modify this production function to account for human capital and raw materials. In their paper titled "A Contribution to the Empirics of Economic Growth", Mankiw, Romer and Weill (1992) made a strong case for the inclusion of a measure of human capital in the production function to explain differences in growth between countries. They showed that including a proxy for human capital lowers the estimated effects of saving and population growth on production growth, suggesting that excluding human capital accumulation from the production function can result in biased outcomes. They were able to show that this augmented model better explains differences in income between countries. We will therefore include human capital in the model.

Furthermore, given that the countries examined in this study are resource-heavy and that Chinese financing is largely focused on the extraction of natural resources, we need to include a measure of raw materials or natural resources in our production function. Baptist & Hepburn (2013) argue that the exclusion of material use from the production function can lead to inaccurate conclusions about factors that contribute to growth and productivity. Most papers argue that raw materials are considered intermediate goods that are indirectly accounted for when the production of final goods is measured. However, it is important to note that extractive economies such as Nigeria and Angola do not use these natural materials as intermediaries in the production of other goods; instead, they export them as raw materials. Therefore, we need to include a measure of raw materials in our production function.

After applying these two amendments to the original Solow production function, our new function is as follows.

$$Y = A K^{\alpha} L^{\beta} H^{\gamma} R^{1-\alpha-\beta-\gamma} \quad (2)$$

Where: $\alpha,\ \beta,\ and\ \gamma$ are rational numbers such that $0 < \alpha,\ \beta,\ \gamma < 1$ and $\delta = 1 - \alpha - \beta - \gamma$.

In this function, Y represents output, A is our measure of productivity (TFP), K is physical capital, L is a measure of the population engaged in productive activity, H is a proxy for human capital accumulation and R is a measure of raw materials. These exponents define the share of output spent on the respective input factors or the elasticity of production with respect to the input factor.

V. Variables and Sources of Data

A. Dependent Variable: Total Factor Productivity

The main dependent variable of interest in this study is productivity. The theoretical section clearly elaborated the equations and assumptions that will be used to generate the productivity variable. GDP data is critical to this exercise. GDP (Y) is the total output produced in a country during a given year. The data in the Penn World Tables lists real GDP at constant 2011 prices. Physical capital (K) is measured as capital stock (investment in 4 main assets: structures (including residential and non-residential), machinery (including computers, communication equipment and other machinery), transport equipment and other assets (including software, other intellectual property products, and cultivated assets). Labor (L) is measured as the number of persons engaged in productive work. Both these data series are found in the Penn World Tables which covers a longer time frame, has a more complete series and contains more macroeconomic variables than other sources such as the World Bank database.

The proxy for human capital (H) is the Human Development Index (HDI). HDI is a summary measure of average achievement in the key dimensions of health and education, ranging from 0 to 1. This time series data starts in 1990 and is calculated by the United Nations Development Program (Human Development Index (HDI) | Human Development Reports, 2019). Unlike other measures of human capital such as the human capital index found in the Penn World tables that only focuses on education, the HDI is an aggregate of both health and education measures. Given that health is an important contributor to productive labor, the HDI is a better measure of human capital. Lastly, the proxy for raw materials (R) will be resource rent. Total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents as a percentage of GDP. While this is not a direct measure of raw materials and could potentially create bias estimates of GDP (Y) as specified in equations 1 and 2, it gives us a good sense of the amount of natural resources in a country. Below is a summary statistics table, with the mean and standard deviation of the four variables used to derive the Solow residual.

Table 1: Summary Statistics of Growth Rates of Input Factors in the Production Function

Variable	Obs.	Mean	Std. Dev.	Min	Max
Real GDP	196	.052	.037	-.141	.14
Capital Stock	196	.111	.09	-.109	.602
Employment	196	.032	.02	-.051	.153
HDI	196	.015	.011	-.021	.063
Resource Rent	196	-.016	.27	-.995	1.152

Table 1 shows the summary statistics of the growth rates of real GDP, capital stock, HDI and resource rent. We see that on average, the growth rates of GDP, capital sock, HDI and employment are increasing while resource rent is decreasing over time. The standard deviation in all five variables suggests sufficient variation in growth rates between countries and across time.

From these variables, TFP is generated. Table 2 gives a summary of this variable. It is clear that there is more variation in TFP across countries than within. This means that countries did not experience significant increases or decreases of productivity during the period between 2003 and 2017. It also suggests that there is significant variation in country characteristics that contribute to productivity.

Table 2: Total Factor Productivity (A) Summary Table

Variable		Mean	Std. Dev.	Min	Max	Observations
Log(A)	overall	10.544	0.839	9.174	12.174	N = 210
	between		0.859	9.420	12.028	n=14
	within		0.128	10.093	10.980	T= 12

B. Independent Variable: Chinese Financing

The independent variable of interest is the amount of Chinese financing funneled into the countries. This study will use two different measures of Chinese financing – FDI and contract value. The data is primarily collected from the China Africa Research Initiative at the John Hopkins School of Advanced International Studies (CARI-SAIS). This dataset tracks Chinese FDI to African countries during the time period of 2003-2017. The other financing variable is the contract value of projects that China services. This data is available in the Chinese Commerce Yearbooks under the Economic Cooperation section and covers the time period between 2003 and 2017.

We will be using the Johns Hopkins dataset because it has been carefully put together by social scientists at CARI-SAIS who used several sources to corroborate the data. It is nonetheless important to note the limitations with Chinese investment data as the Chinese government is not transparent about its finances. There are two other sources – the American Enterprises Institute and the United Nations Conference on Trade and Development – that could be used instead of the data from CARI-SAIS. However, the American Enterprises Institute has a limited time series and only has information on investments greater than $100million. The UNCTAD has a shorter time series than does CARI-SAIS.

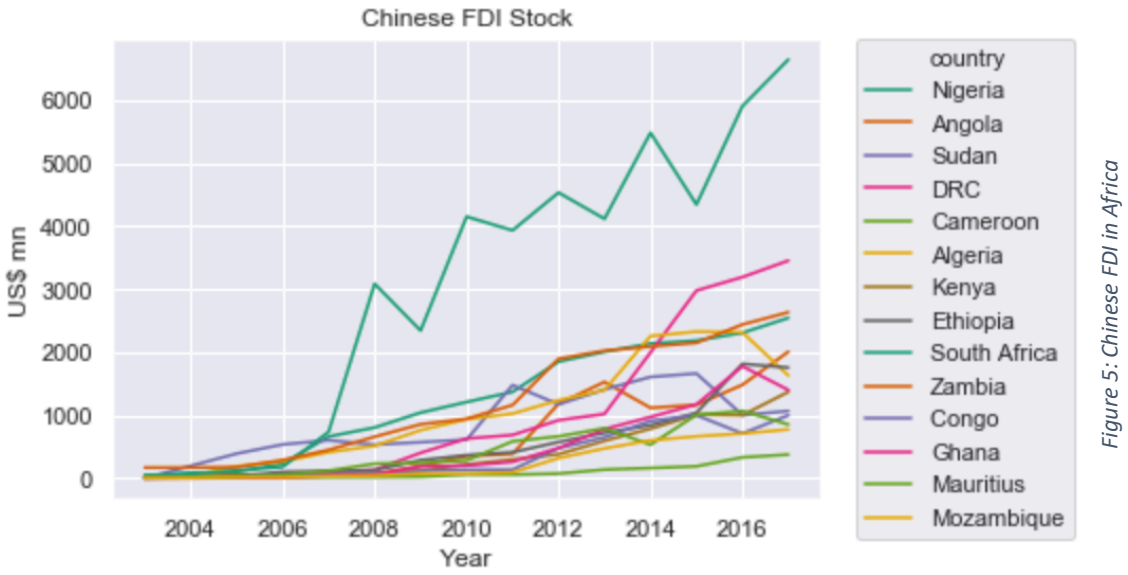


Figure 5: Chinese FDI in Africa

As shown in the Figure 5, the volume of Chinese FDI has been increasing significantly over the time period between 2003 and 2017 in all fourteen countries. We see an exponential increase in these amounts in the first 5-8 years, but this growth tapers off towards the end of the time period. This tapering off might be explained by China's slowing economic growth. South Africa received the largest amount of Chinese FDI with $48billion over these 14 years while Cameroon received the lowest amount with $1.6billion over the same time period. South Africa is

the largest and most institutionally-sound economy. This might explain why South Africa attracts the highest level of FDI and has the highest level of Chinese FDI growth.

On the other hand, inspection of the time-series plots for the contract value indicate that the trend is not as clear as the FDI trend. This is largely because of the nature of construction and oil extraction projects. For instance, in Nigeria, about $1.75 billion was provided for an oil extraction project but this value drops to about $0.5billion in 2016 once this project has been financed. Therefore, the time trend of contract value depends on the number, type and time duration of projects that are being implemented within a given year.

In order to make the trends more visible, I've categorized the countries in my sample into three groups based on their value of resource rents. The expectation here is that countries in the high-resource group will outperform countries in medium and low resource groups in terms of contract value. This is largely because China tends to invest more heavily in resource rich countries. However, we see that this is not always the case. Nigeria has the highest contract value even though it is classified as a medium resource group. This might be because resource rent, the proxy for the value of raw materials in a country, is not a perfect measure of resource wealth since it is also reflective of prices and technological efficiency.

Contract Value within Resource Group

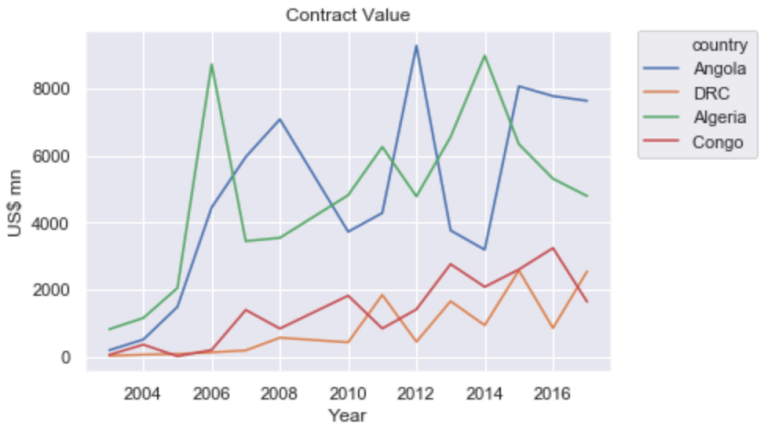


Figure 7: Medium Resource Countries (% of GDP)

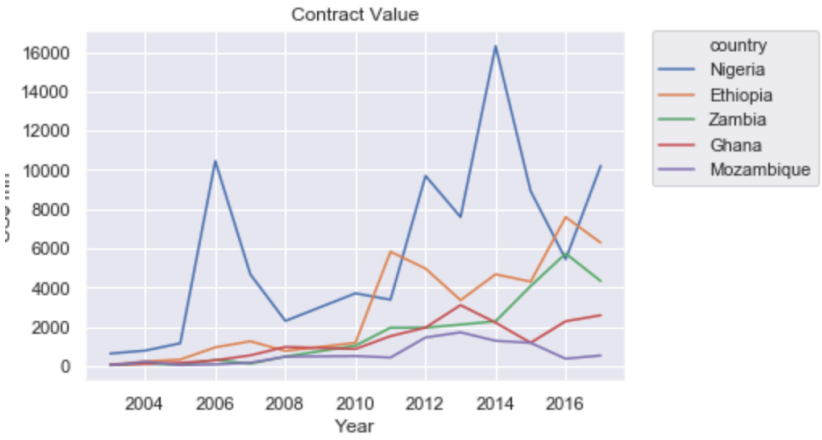


Figure 6: Low Resource Countries (% of GDP)

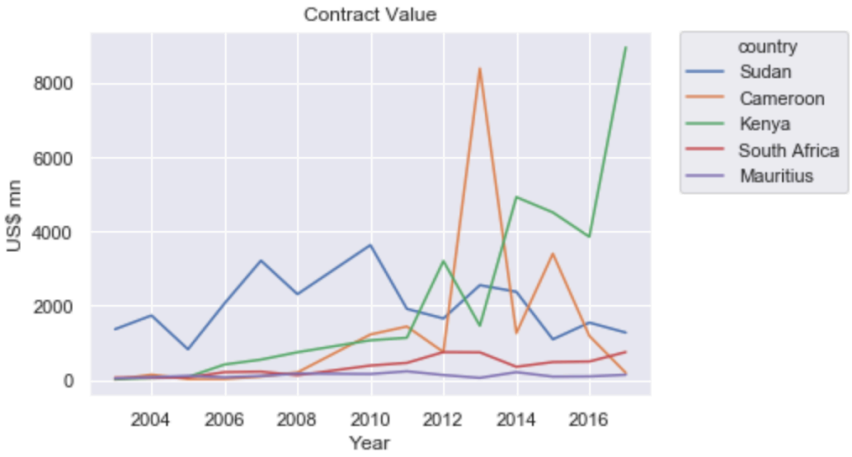


Figure 8: Low Resource Countries (% of GDP)

C. Other Explanatory Variables

Trade openness – imports and exports as a share of GDP – allows us to control for a country's exposure to the international market and its experience with foreign trade. Furthermore, a country with a higher trade openness is more likely to attract Chinese investment, thereby making this variable central to determining China's choice of countries to invest in. This was found in the World Bank microdata database.

Manufacturing's share of GDP will serve as a proxy for a country' level of industrial development. A country in the very early stages of the industrial development likely has a lower capacity to absorb the transfer of technology associated with FDI inflows. This data was found in the World Bank Database. The DRC has the largest manufacturing sector, accounting for 18% of the value added to GDP. This could be explained by the large mining sector excavating its large natural resource base.

Measure of institutional quality will serve as a proxy for the potential misallocation of funds by the receiving country. Higher levels of corruption will likely reduce the positive productivity benefits of Chinese FDI inflows. We also want to evaluate a country's institutional strength in order to determine the ease of doing business within the recipient country. This data is collected from the Worldwide Governance Indicators (WGI), a large research database summarizing the views on the quality of governance from surveys administered to citizens, enterprises and experts. This study focuses on three of their six indicators – regulatory quality (enforcement of the law), government effectiveness (quality of policy formation and implementation) and rule of law (protection of property rights. I believe that these three indicators will give a holistic sense of a country's ability to attract, absorb and effectively utilize external financing. Each is an index ranging from -2.5(weak) to 2.5(strong).

Human capital will serve as a measurement of the skills, knowledge and abilities of the recipient country's population. Technological transfer will only increase productivity if the local population is able to absorb and utilize these new ideas and processes. The Human Development Index (HDI) is employed here as a proxy for human capital. HDI is a summary measure of average achievement in the key dimensions of health and education, ranging from 0 to 1. This time series data starts in 1990 and is found on the UNDP website. For a quick glance, we can see that Algeria has the highest HDI value at 0.754 while the DRC reports the lowest value of 0.457.

Internet access and mobile phone penetration will measure a country's access to technology. Given the importance of internet access and technology to an individual's or business' ability to access resources, it is an important contributor to human capital. This data is found in the World Bank Database. As of 2017, South Africa has the largest internet penetration rate with 56% of its population having used the internet in the past 3 months. The DRC has the lowest with a value of 9%.

Table 3 provides summary statistics for the independent and control variables. We can see that there is significant variation within all the variables. On average, contract value is greater than the value of Chinese FDI. Rule of law and government quality are negative on average, indicating that governance systems are weak and business environments are not very conducive to economic activity[5]. Table 3 also includes a measure for FDI flows from other countries. On average, this value is 25 times the value of FDI flows from China.

[5] Recall that government quality and rule of law are measured on a scale of -2.5 to 2.5.

Table 3: Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Chinese FDI	196	890.856	1135.735	.543	6647.688
Other FDI	196	22811.38	33712.5	866.469	175000
Contract value	196	2336.12	2739.992	18.825	16316.62
Trade openness	196	67.654	29.584	15.975	148.587
Gov't quality	196	-.633	.651	-1.661	1.085
Rule of law	196	-.703	.663	-1.72	1.03
Manufacturing	196	12.242	9.552	3.399	50.637
Internet Access	196	12.914	13.411	.155	56.167

A correlation matrix will help us understand the relationship between variables in the raw dataset. Table 4 below shows the correlation between the variables discussed in this section. There are some insights that can be gleaned from this matrix. Firstly, there is a positive correlation between GDP and FDI suggesting that Chinese companies seek to invest in more developed countries. Furthermore, Chinese FDI and HDI are positively correlated, indicating that companies choose to invest in countries whose population is more educated and healthier. Secondly, human capital (proxied by HDI) is strongly positively correlated with governance quality, rule of law and internet access. Countries whose governments are more committed to quality infrastructure and governance systems tend to have higher HDI scores. In addition, we see a negative correlation between resource rent and government quality. This adds to the common narrative that extractive economies have poor quality of governance since they are less accountable to their constituencies. Lastly, trade openness is negatively correlated with real GDP. This is consistent with the conjecture that trade in Africa is geared heavily towards the extraction of natural resources (Fadiran & Akanbi, 2017).

Table 4: Matrix of correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Real GDP	1.000										
(2) HDI	0.303	1.000									
(3) Resource Rent	-0.107	-0.209	1.000								
(4) Chinese FDI	0.534	0.346	-0.142	1.000							
(5) Other FDI	0.736	0.251	-0.108	0.659	1.000						
(6) Contract value	0.473	0.139	0.147	0.238	0.144	1.000					
(7) Trade openness	-0.369	0.294	0.405	-0.154	-0.124	-0.175	1.000				
(8) Gov't quality	0.093	0.619	-0.606	0.151	0.262	-0.265	0.178	1.000			
(9) Rule of law	0.007	0.628	-0.553	0.166	0.151	-0.229	0.220	0.942	1.000		
(10) Manufacturing	0.280	0.478	-0.006	0.042	-0.028	0.114	-0.035	0.111	0.096	1.000	
(11) Internet access	0.366	0.679	-0.408	0.686	0.390	0.160	0.032	0.495	0.524	0.139	1.000

Several databases were used to compile this dataset. Special attention was put when merging different datasets. Note that all variables in dollar terms have been corrected for inflation. Appendix A presents a summary of data sources with short descriptions of each as well as criticisms or problems with each dataset.

VI. Empirical Methodology

The methodology for this study utilizes a two-stage regression procedure. The first stage will generate the total factor productivity measure for each country, during each year between 2003 and 2017. The second stage then regresses Chinese financing and several control variables on this measure of productivity.

A. Stage 1: Generation of Total Factor Productivity

From (2) above, we have our production function:

$$Y = AK^{\alpha}L^{\beta}H^{\gamma}R^{\delta}$$

Taking the natural logarithm of both sides, we get:

$$lnY = lnA + \alpha lnK + \beta lnL + \gamma lnH + \delta lnR$$

Where: $\delta = 1 - \alpha - \beta - \gamma$.

Note that taking the natural logarithm reduces the influence of outliers. Moreover, the growth literature often explores GDP growth and taking the natural logarithm is the first step of doing so. Next, since all these variables represent time-series data, we need to adjust when necessary for stationarity. To check for stationarity, the Augmented Dicky Fuller (ADF) test was ran on these five variables. The test showed that all five variables are non-stationary. The results are shown in Appendix B. Thus, to avoid picking up the impact of the time trend, we take the first difference estimation.

$$lnY_{it} - lnY_{i(t+1)}$$
$$= \left(lnK_{it} - lnK_{i(t+1)}\right) + \left(lnL_{it} - lnL_{i(t+1)}\right) + \left(lnH_{it} - lnH_{i(t+1)}\right)$$
$$+ \left(lnR_{it} - lnR_{i(t+1)}\right) + u_{it} + \varepsilon_{it}$$

This equation can now be simplified as:

$$\hat{Y} = \hat{K} + \hat{L} + \hat{H} + \hat{R} + u_{it} + \varepsilon_{it}$$

Where: $\hat{Y} = lnY_{it} - lnY_{i(t+1)}$, $\hat{K} = lnK_{it} - lnK_{i(t+1)}$, $\hat{L} = lnL_{it} - lnL_{i(t+1)}$, $\hat{H} = lnH_{it} - lnH_{i(t+1)}$ and $\hat{R} = lnR_{it} - lnR_{i(t+1)}$,

Running the ADF test on these constructed values shows that these variables are now stationary. Results are again shown in Appendix B. After taking the natural logarithm of both sides and taking the first difference estimator, the residual of this production function will be interpreted as the growth of productivity. Next, to check for serial correlation error, the Jochman's Portmanteau test is run on the data. With a p-value of 1, we can be certain that the regression does not suffer from serial correlation.

Islam (1995) showed in his paper that when running cross-country growth regressions, it is important to include country specific dummy variables that account for differences in culture,

endowment, institutions etc. We thus include country-specific dummies u_{it} for the thirteen countries in the fixed effects model (excluding South Africa as the benchmark country).

After predicting output values using observations of physical capital, human capital, labor, and resource rent, we will use the coefficients in specification 4 to derive the unexplained measure of GDP using the following equation[6].

$$A = \frac{Y}{K^{\alpha} L^{\beta} H^{\gamma} R^{\delta}}$$

B. Stage 2: Regression on TFP

Once we generate our measure of productivity, we can now regress measures of Chinese financing and the control variables on this generated variable. The equation is as follows:

$$\begin{aligned}\log(A)_{it} = {} & \alpha log(Chinese\ FDI)_{it} + a_1 log(Total\ FDI - Chinese\ FDI)_{it} \\ & + a_2 log(Contract\ Value) + a_3(Trade\ Openness)_{it} \\ & + a_5(Manufacturing's\ Share\ of\ GDP)_{it} + a_6(Gov't\ quality)_{it} \\ & + a_7(Rule\ of\ Law)_{it} + a_8(Internet\ Access) + a_8(Chinese\ FDI * HDI) + \varepsilon_{it}\end{aligned}$$

VII. Findings

A. First Stage Regression

The first-stage regression is composed of growth regressions to derive levels of productivity for each country, during each time period. Table 5 below shows the results of four different regression models, each exploring growth instead of absolute values. In specification 1, capital stock and employment are included to replicate the original Solow model. In specification 2, human capital is included as per the improvement of Mankiw and Romer. In specification 3,

[6] Several studies such as Fadiran & Akanbi's (2017) paper that generate values for total factor productivity from a production function have done so in this manner.

resource rent is included to account for the extractive nature of the countries involved. In the last specification, country-specific country dummies are included to account for time invariant, country dependent unobservable factors. The benchmark country in this last specification is South Africa.

From table 5 below, we can observe that capital stock, employment, HDI and resource rent are all significant at the 0.05 level, regardless of the model specification used. However, the magnitude of these coefficients changes as we include HDI, resource rent and country-specific dummies. This suggests that each prior regression is omitting important variables and allowing the coefficients to absorb the impact of these omitted variables. The increase of the value of the coefficient on physical capital from (3) to (4) indicates that capital is employed more efficiently when countries have higher levels of institutional capacity – a variable captured by the country dummies. Similarly, the coefficient on human capital decreases as we include country dummies since variables such as institutional quality are crucial for the accumulation of human capital. The coefficient on HDI in specification 3 was thus absorbing the impact of omitted factors such as institutional quality. This supports Fadiran and Akanbi's (2017) finding that including a measure of institutional quality reduces the explanatory power of human capital.

Interestingly, the coefficients on capital stock, employment and HDI change the most when country dummies are included. This suggests that there are significant country-dependent, time-invariant characteristics that are being omitted. Examples could be quality of governance institutions and colonial history. Note that the DRC, Ethiopia, Ghana, Kenya and Mozambique are the only countries that exhibit statistically significant coefficients. This might be due to the small sample size per country (14 years) that limits the software's ability to correctly identify this country-specific heterogeneity. Given that fourteen years only accounts for a little over two business cycles at best, it is very unlikely that the coefficients on the dummy variables accurately

capture time-invariant, country characteristics. Since equation 4 includes more explanatory variables and has a significantly higher adjusted R-squared, it will be used to derive TFP.

Table 5: Growth Regression Results

VARIABLES	(1) GDP	(2) GDP	(3) GDP	(4) GDP
Capital Stock	0.0993***	0.0812***	0.0750***	0.116***
	(0.0280)	(0.0269)	(0.0266)	(0.0308)
Employment	0.395***	0.285**	0.259**	0.264**
	(0.126)	(0.122)	(0.120)	(0.122)
HDI		1.023***	1.128***	0.549**
		(0.221)	(0.221)	(0.230)
Resource Rent			0.0239***	0.0223***
			(0.00887)	(0.00828)
Algeria				0.00589
				(0.0116)
Angola				0.0155
				(0.0121)
Cameroon				0.0119
				(0.0115)
Republic of Congo				-0.0101
				(0.0118)
DRC				0.0303**
				(0.0120)
Ethiopia				0.0572***
				(0.0123)
Ghana				0.0283**
				(0.0117)
Kenya				0.0192*
				(0.0116)
Mauritius				0.0184
				(0.0115)
Mozambique				0.0246**
				(0.0118)
Nigeria				0.0107
				(0.0117)
Sudan				-0.00644
				(0.0124)
Zambia				0.0222*
				(0.0117)
Constant	0.0282***	0.0179***	0.0182***	0.00618
	(0.00568)	(0.00584)	(0.00575)	(0.00893)
Observations	196	196	196	196
R-squared	0.103	0.193	0.223	0.388
Adjusted R-squared	0.0941	0.1805	0.2065	0.3295

Standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

B. Second Stage Regression

In the second stage regression, we explore the relationship between Chinese financing and productivity, accounting for the control variables discussed above. We ran four different regressions, each time adding more explanatory variables. In specification (1), we only include financing variables, i.e. Chinese FDI, FDI from other countries and contract value. In specifications (2) and (3), we include country-level characteristics that are important determinants of productivity levels. The last specification includes an interaction term between Chinese FDI and HDI to test for the human capital level-dependent effects of Chinese FDI.

In all regressions, Chinese FDI seems to have a negative relationship with productivity, with the coefficients in (3) and (4) showing statistical significance. This suggests that there is no technological transfer between Chinese firms in Africa and local firms. This might be due to the relative backwardness of African firms that prevents them from taking advantage of the transfer of technology. Moreover, given that Chinese companies avoid hiring local labor, the channel of technology transfer is disrupted. In fact, Chinese FDI seems to have a negative effect on productivity which could be explained by a detrimental level of competition between local and Chinese companies and the disruption of existing networks between local businesses. In this case, the benefits of external capital are outweighed by its costs.

However, the interaction term between Chinese FDI and HDI is positive, indicating that if a country has high levels of human capital accumulation, Chinese FDI can have positive impacts on productivity. This supports Borensztein et. al. (1995)'s argument about absorptive capacity. Populations that are more educated and healthier are more capable of absorbing the skills and any technology transferred with Chinese FDI. Lastly, FDI from other countries has a strong positive impact on productivity, suggesting that there is something different about Chinese FDI. This could

be largely explained by the destination of Chinese FDI and the lack of conditionality that is characteristic of Chinese investment.

On the other hand, there is a strong relationship between contract value and productivity in all four specifications. We've seen that China is increasing its attention towards the transport and manufacturing sectors. Construction of roads and railways supports business activity, reduces cost of traveling for workers and facilitates exports and imports, all contributing to productivity. While it is possible to argue that the financing of contracted projects can have the same competition effects as FDI, such projects require significant technical and logistical capacity that African countries often lack. Thus, given that Chinese companies are filling existing gaps instead of taking over from local companies through the contracted projects, the competition effects might not be as pronounced. Similarly, investment in the manufacturing sector can spur productivity and support the industrialization of the continent. From the table below, we can see that an increase in the share of manufacturing value added is associated with an increase in productivity. Thus, given the focus of contracted projects, such forms of financing can have positive impacts on productivity.

The coefficients on government quality present an expected relationship between quality of governance and productivity. A country with a more efficient, less corrupt government that adheres to regulations can facilitate business activity and provide critical public goods and services to its citizens. Public goods such as transportation, education and healthcare are fundamental to increasing worker productivity and reducing transaction costs, consequently increasing overall productivity. However, the coefficient on rule of law is negative and statistically significant. The rule of law index captures perceptions of the extent to which citizens and businesses have confidence in the government's ability to enforce contracts and property rights and their belief in the quality of the police and courts. An increase in rule of law in Africa would decrease the size of

the informal sector which is a significant contributor to GDP. This might explain why the coefficient on rule of law is negative. Moreover, internet access seems to be negatively associated with productivity. While this result is counterintuitive, the value of the coefficient is essentially zero. This most likely reflects the lack of internet coverage overall and the relatively low usage of internet in the workforce on the African continent.

Trade openness seems to have a negative relationship with productivity. The current literature argues that trade openness positively impacts productivity by allowing the transfer of goods, services, technology and skills across borders (Abizadeh & Pandey, 2009). Trade liberalization is often cited as a major contributor to growth in China and in the four Asian tigers, Hong Kong, Singapore, South Korea and Taiwan. However, the import and export portfolios of African countries are not as conducive to improvements in productivity. As shown in Appendix C and D, Africa largely exports raw materials such as oil and gas, rare metals as well as food and drinks while it imports manufactured consumer goods, machinery and pharmaceuticals[7]. From this, we can see that Africa has not undergone a robust industrialization phase that is often correlated with greater R&D efforts and an absorption of a large number of workers into productive jobs (Signé, 2018). Given that Africa largely exports raw materials and imports finished products, an increase in trade openness might negatively contribute to productivity. This finding suggests that trade in Africa is a substitute rather than a complement for domestic capacity building – heavily extractive trade diminishes domestic capability (Fadiran & Akanbi, 2017).

[7] Refer to Appendix D

Table 6: Second Stage Regression Results

VARIABLES	(1) Log (TFP)	(2) Log (TFP)	(3) Log (TFP)	(4) Log (TFP)
1) Chinese FDI	-0.0259	-0.0311	-0.0850***	-2.062***
	(0.0280)	(0.0220)	(0.0245)	(0.211)
2) Contract Value	0.0749**	0.0654**	0.147***	0.0622***
	(0.0334)	(0.0268)	(0.0271)	(0.0237)
3) Other FDI	0.457***	0.455***	0.427***	0.415***
	(0.0426)	(0.0328)	(0.0328)	(0.0266)
4) Trade Openness		-0.681***	-0.727***	-0.953***
		(0.0759)	(0.0732)	(0.0639)
5) Manufacturing Value		0.370***	0.294***	0.110**
		(0.0554)	(0.0519)	(0.0463)
6) Gov't quality			0.562***	0.318**
			(0.163)	(0.135)
7) Rule of law			-0.237	-0.279**
			(0.156)	(0.126)
8) Internet access			0.00456	-0.00566*
			(0.00388)	(0.00332)
9) HDI*Chinese FDI				1.980***
				(0.210)
10) Constant	5.970***	8.038***	8.530***	11.79***
	(0.334)	(0.464)	(0.438)	(0.495)
Observations	181	176	174	174
R-squared	0.528	0.730	0.788	0.862
Adjusted R-squared	0.520	0.722	0.777	0.855

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Variables 1,2,3,5,9 are expressed in logarithms.

VIII. Conclusion

In this paper, we explored the impact of Chinese financing on productivity levels in the African continent, looking specifically at the top fourteen recipients during the period between 2003 and 2017. Using a revised version of the Solow model, we generated values of productivity that were then used in the second stage regression process. In this stage, we regressed productivity on Chinese financing variables, accounting for several control variables such as trade openness, institutional quality and manufacturing value-added. Results from the first stage regression process

indicate that human capital allocation and natural resource wealth need to be included in any growth regression concerning Africa. This is especially true when focusing on countries that are extractive. The coefficients on all four explanatory variables – capital stock, employment, HDI and resource rent – are positive and significant. The inclusion of country dummies reduced the explanatory power of human capital and increased that of physical capital. This suggests that physical capital is employed more efficiently in countries with higher institutional quality while the coefficient on HDI had initially captured the impact of unobserved factors such as governance quality when country dummies were omitted.

Results from the second stage regression indicate that Chinese FDI has a negative impact on productivity while government loans, proxied by contracted projects, has a positive one. A possible explanation is the technological backwardness of African firms that prevents absorption of technological spillovers from FDI. On the other hand, due to the focus of contract projects on transportation and the manufacturing industry, they have a positive impact on productivity. Contrary to the literature on TFP, the coefficient on trade openness is negative. However, given that the manufacturing and industrial sectors in many African countries are weak and that exports from African countries are resource extractive, an increase in trade might negatively impact productivity. Quality of government has a positive impact as expected while rule of law has a surprisingly negative one. This might be because an increase in property rights and contract enforcement puts constraints on the informal sector, the largest sector in most African countries. Lastly, we've seen that the interaction term between Chinese FDI and HDI is positive, suggesting that countries that have higher level of human capital accumulation are better equipped to take advantage of FDI. Governments should look towards attracting more Chinese government loans while working to improve the absorptive capacity of domestic firms to benefit from FDI.

Finally, I am aware of the empirical limitations of this study. For one, the number of observations per country is extremely limited, making us less certain about the OLS estimates. Secondly, the adjusted R-squared values from the first-stage regression values are low with a maximum value of 0.33 in the last specification. While this is common in growth regressions, we need to be cautious about the generated values of productivity. Lastly, the lack of transparency of the Chinese government makes it difficult to fully trust data on FDI and contract value. While this study used data thoroughly cross-checked and aggregated by experts from CARI-SAIS, we nonetheless have to be cautious of this data. Further research should explore more robust and fully encapsulating measures of productivity that rely on more advanced economic growth models. In order to provide better recommendations on how African governments should work with China, country-specific analysis should be carried out.

IX. Appendices

A. Summary of Sources

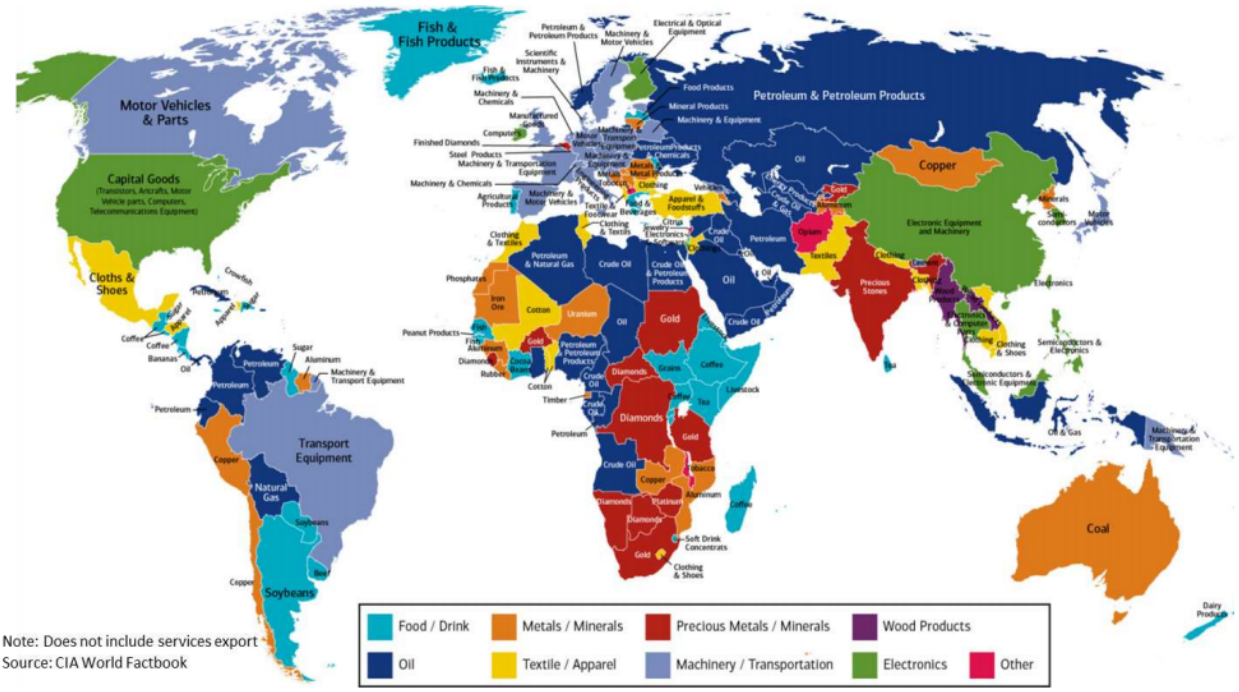
Data Source	Time Period and # of Countries	Overview	Problems
CARI SAIS Database	2003-2017, 54 countries	Contains detailed data on China-African relations including data on Chinese FDI, loans, contract values etc. Developed through rigorous data collection and cross validation with various sources	The Chinese government is not very transparent with its outward investment. Contained unadjusted values for all variables so I converted to constant prices
Penn World Tables	1950-2017, 182 countries	Set of national-accounts data containing macroeconomic variables such as output, capital stock, population engaged in work etc.	Difficulty of accurately measuring macroeconomic variables
Human Development Index	1980-2018, 189 countries	Reports a summary measure of average achievement in the key dimensions of health, education and standard of living and ranks countries based on this measure	Simplifies the concept of human development as it does not account for inequality, poverty, security
World Bank	Depends on the variable of interest	Contains time-series data on several national macroeconomic variables such as trade-openness, manufacturing's share of GDP, internet access etc.	Difficulty of accurately measuring macroeconomic variables
World Governance Indicators	1996-2018, 200 countries	Summarizes individual, enterprise and expert views on the quality of six different dimensions of governance such as government effectiveness, regulatory quality, rule of law etc.	Has been criticized for a lack of conceptual clarity regarding the six dimensions of governance and for hidden biases that guide the weighting of different views

B. Panel Unit Root Test Results

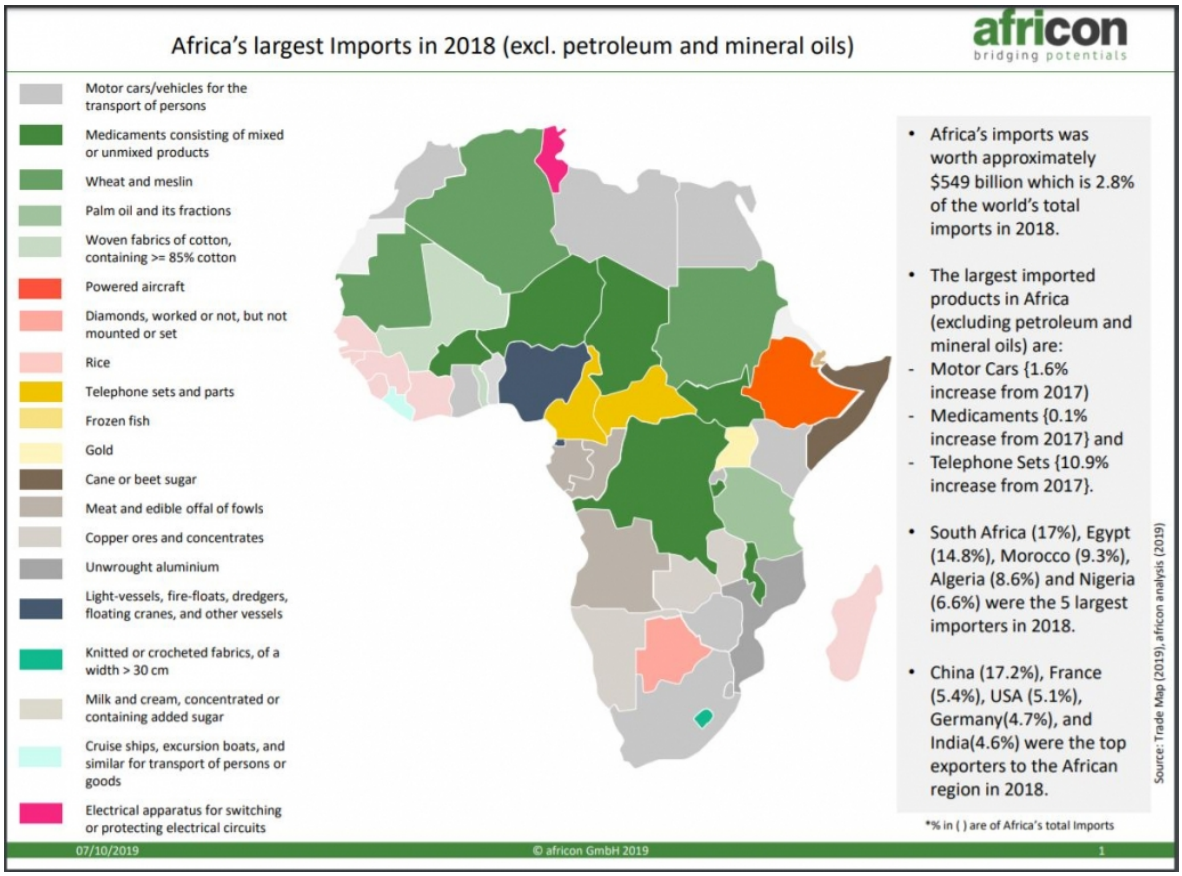
	Inverse chi-squared (28) (P)	Inverse normal (Z)	Inverse logit t (74) (L*)	Modified inv. chi-squared (Pm)
Y	27.3081 (0.5015)	0.8497 (0.8022)	1.0297 (0.8468)	-0.0925 (0.5368)
K	30.7284 (0.3293)	0.3863 (0.6504)	0.5815 (0.7187)	0.3646 (0.3577)
L	32.5948 (0.2510)	3.6920 (0.9999)	3.7738 (0.9998)	0.6140 (0.2696)
H	32.8292 (0.2421)	-0.4024 (0.3437)	-0.4376 (0.3315)	0.6453 (0.2594)
R	25.7450 (0.5871)	-0.1255 (0.4501)	-0.1073 (0.4574)	-0.3013 (0.6184)
ΔY	63.5998 (0.0001)	-2.9950 (0.0014)	-3.4201 (0.0005)	4.7572 (0.0000)
ΔK	73.0519 (0.0000)	-3.3210 (0.0004)	-3.5878 (0.0003)	6.0203 (0.0000)
ΔL	40.8890 0.0550	-0.7293 0.2329	-1.0845 0.1408	1.7224 (0.0425)
ΔH	119.7693 (0.0000)	-5.7648 (0.0000)	-7.9772 (0.0000)	12.2632 (0.0000)
ΔR	79.0578 (0.0000)	-5.5957 (0.0000)	-5.6519 (0.0000)	6.8229 (0.0000)

* Y, K, L, H and R are all measured in log
*P statistic requires number of panels to be finite.
*Other statistics are suitable for finite or infinite number of panels.
*P-value in brackets.

C. Worldwide major exports by country



D. Africa's largest imports



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